STATE OF THE ART REPORT ON THE MANAGEMENT OF BIOMEDICAL (TYPE A) WASTES IN CANADA

Contaminants Assessment Branch
Conservation & Protection
Atlantic Region
Environment Canada

Prepared for

Industrial Programs Branch
Conservation & Protection
Environment Canada

IP-81
February 1988

STATE-OF-THE-ART REPORT ON THE MANAGEMENT OF BIOMEDICAL (TYPE A) WASTES IN CANADA

Environmental Protection Service
Conservation and Protection
Environment Canada
Atlantic Region

February, 1987

STATE OF THE ART REPORT ON THE MANAGEMENT OF BIOMEDICAL (TYPE A) WASTES IN CANADA

Contaminants Assessment Branch
Conservation & Protection
Atlantic Region
Environment Canada

Prepared for

Industrial Programs Branch
Conservation & Protection
Environment Canada

This report has had limited review by Conservation and Protection and the content does not necessarily reflect the views and policies of Environment Canada. Mention of trade names for commercial products does not constitute endorsement for use. This distribution is not intended to signify publication and, if the report is referenced, the author should cite it as an unpublished report of Environment Canada.

Any comments concerning its content should be directed to:

D. Campbell
Waste Management Division
Industrial Programs Branch
Conservation & Protection
Environment Canada
Ottawa, Canada
K1A 0H3

TABLE OF CONTENTS

		Page
ABSTRACT		iv
RÉSUME		v
LIST OF TABLES		vi
LIST OF FIGURES		vii
1	INTRODUCTION	1
1.1	Purpose	1
1.2	Legislative Mandate	1
1.3	Biomedical Type A Waste Definition	1
2	WASTE GENERATORS	3
3	WASTE GENERATION	6
3.1	Characteristics of Wastes	6
3.1.1	Hospitals	6
3.1.2	Veterinary Services	9
3.1.3	Medical and Other Health Laboratories	9
3.1.4	Research and Development Laboratories	9
3.2	Waste Generation Rate	9
3.2.1	Hospitals	10
3.2.2	Other Sources	12
3.2.2.1	Veterinary services	12
3.2.2.2	Medical	12
3.2.2.3	Research and development laboratories	13
4	CURRENT MANAGEMENT PRACTICES	16
4.1	Hospitals	16
4.2	Veterinary Services	17
5	BEST AVAILABLE MANAGEMENT TECHNOLOGIES	23
5.1	Storage	23
5.1.1	Primary Storage	23
5.1.2	Waste Holding and Pre-disposal	23
5.2	Transportation	24
5.2.1	Handling	24
5.2.2	On-site Transportation	24
5.2.3	Off-site Transportation	28
5.3	Treatment Technologies	30
5.3.1	General	30
5.3.2	Steam Sterilization	30
5.3.3	Dry Heat Sterilization	31

		Page
5.3.4	Gas/Vapor Sterilization	32
5.3.5	Chemical Disinfection	32
5.3.6	Irradiation	33
5.3.7	Reduction, Recycling and Reuse	33
5.4	Disposal	35
5.4.1	Incineration	35
5.4.1.1	General	35
5.4.1.2	Types of incinerators	35
5.4.1.3	Operation	42
5.4.1.4	Emission	42
5.4.2	Landfill	44
5.4.3	Sanitary Sewer	46
6	GUIDELINES AND RELATED DOCUMENTS	48
6.1	Provincial and Territorial	48
6.1.1	British Columbia	48
6.1.2	Saskatchewan	48
6.1.3	Manitoba	49
6.1.4	Ontario	49
6.1.5	Quebec	53
6.2	National	53
6.2.1	Agriculture Canada	53
6.2.2	Canadian Standards Association	56
6.2.3	Canadian Society of Hospital Pharmacists	56
6.2.4	Environment Canada	56
6.2.5	Medical Research Council of Canada	58
6.2.6	Campbell, B.A., Pequegnat, M.D. Clayton, A.J.	59
6.2.7	Treasury Board of Canada	60
6.3	Others	61
6.3.1	U.S. Environmental Protection Agency	61
6.3.2	World Health Organization	61
7	LEGISLATION	64
7.1	Provincial	64
7.1.1	British Columbia	64
7.1.2	Alberta	64
7.1.3	Manitoba	65
7.1.4	Ontario	65
7.1.5	Quebec	66
7.1.6	New Brunswick	68
7.1.7	Newfoundland	68
7.2	Federal	69
7.2.1	Agriculture Canada	69
7.2.2	Fisheries and Oceans Canada	69
7.2.3	Transport Canada	70
8	CONCLUSIONS AND RECOMMENDATIONS	80

			Page
9	REFERENCES		84
APPENDIX	1		90
	2		92
	3		93
	4		94
	5		95
	6		96
	7		98
	8		99

ABSTRACT

This manual discusses the current management of Biomedical (Type A) Wastes in Canada. Topics covered include a definition of Biomedical Waste as well as an inventory of generators and quantities. The manual also summarizes the various Canadian documents (regulations, protocols, guidelines) and technologies used to manage Biomedical Wastes.

The current management technologies discussed are storage, transport, treatment, disposal, as well as reduction, reuse and recycling. Advantages and disadvantages are given for most of the technologies discussed.

The assessment of the current situation revealed two immediate needs: the development of a national standard definition for Biomedical Wastes and the development of a national environmental code for managing those wastes.

RÉSUMÉ

Ce manuel fait le point sur la gestion actuelle des déchets biomédicaux de type A au Canada. Il présente une définition ainsi qu'un inventaire des quantités et des générateurs de ces déchets. Le manuel résume les différents documents canadiens (réglements, protocoles, lignes directrices) et les différentes techniques existants pour la gestion des déchets biomédicaux de type A.

La gestion des déchets est discutée du point de vue des techniques d'entreposage, de transport, de traitement, de rejet ainsi que de réduction, de réutilisation et de recyclage. Les avantages et les désavantages que présentent ces techniques sont aussi discutés.

L'évaluation de la situation qui prévaut présentement au Canada en matière de déchets biomédicaux a identifié deux importants besoins: l'élaboration d'une définition standard de déchet biomédical ainsi que l'élaboration de lignes directrices touchant la gestion des déchets biomédicaux d'un point de vue environnemental.

LIST OF TABLES

		Page
TABLE 2.1	BED SET UP FOR USE DISTRIBUTED BY SIZE GROUPS	4
TABLE 2.2	NUMBER OF GENERAL HEALTH CARE FACILITIES IN CANADA	5
TABLE 3.1	RELATIVE BREAKDOWN OF MAJOR WASTE PRODUCING AREAS FROM THREE DIFFERENT SIZE HOSPITALS	8
TABLE 3.2	COMPOSITION OF TOTAL HOSPITAL WASTE MASS	8
TABLE 3.3	COMBUSTION PROPERTIES FOR HOSPITAL WASTE	8
TABLE 3.4	SUMMARY OF GENERAL AND BIOMEDICAL HOSPITAL WASTE GENERATION RATES REFERENCED IN AMERICAN AND CANADIAN SOURCES	10
TABLE 3.5	DAILY AND ANNUAL GENERATION OF BIOMEDICAL WASTES IN CANADIAN HOSPITALS	11
TABLE 3.6	VETERINARY SERVICES	13
TABLE 3.7	MEDICAL AND OTHER HEALTH LABORATORIES	14
TABLE 3.8	RESEARCH AND DEVELOPMENT LABORATORIES	14
TABLE 3.9	BIOMEDICAL WASTE GENERATION IN CANADA	15
TABLE 4.1	MANAGEMENT OF BIOMEDICAL WASTES (TYPE A) IN CANADIAN HOSPITALS	18
TABLE 4.2	TREATMENT AND DISPOSAL PRACTICE OF BIOMEDICAL WASTES IN A 450-BED NEW BRUNSWICK PUBLIC GENERAL HOSPITAL	20
TABLE 4.3	TREATMENT AND DISPOSAL PRACTICE OF BIOMEDICAL WASTES IN A 200-BED NOVA SCOTIA PUBLIC GENERAL HOSPITAL	20
TABLE 4.4	MANAGEMENT OF BIOMEDICAL WASTES IN CANADIAN VETERINARY SERVICES	21
TABLE 5.1	ADVANTAGES AND DISADVANTAGES OF WASTE TRANSPORTATION SYSTEMS	
TABLE 5.2	COST PER CUBIC METER OF WASTE FOR THREE STERILIZATION PROCESSES	34
TABLE 7.1	TDGR SCHEDULE VII. INFECTIOUS SUBSTANCES	77

LIST OF FIGURES

FIGURE 5.1	RETORT-TYPE MULTIPLE-CHAMBER PATHOLOGICAL WASTE INCINERATOR	37
FIGURE 5.2	IN-LINE MULTIPLE-CHAMBER INCINERATOR	38
FIGURE 5.3	TYPICAL CONFIGURATIONS OF CONTROLLED AIR INCINERATOR	40
FIGURE 5.4	EFFECTIVE STACK HEIGHT	45
FIGURE 7.1	TDGR SCHEDULE V - PART I, FIGURE 16, CLASS 6, DIVISION 2. INFECTIOUS SUBSTANCE LABEL	73
FIGURE 7.2	TDGR SCHEDULE V - PART IV, FIGURE 3. PACKAGE ORIENTATION	74

1 INTRODUCTION

1.1 Purpose

The purpose of this manual is to document a state-of-the-art review of present methods of management and control of Biomedical Type A wastes in Canada, to characterize these wastes and to describe related treatment and destruction technologies.

1.2 Legislative Mandate

The management of Biomedical Type A wastes is a provincial responsibility. The federal government has concerns about the management of these wastes in accordance with the mandate prescribed by the following legislation:

- Animal Disease and Protection Act
- Fisheries Act
- Transportation of Dangerous Goods Act

1.3 Biomedical Type A Waste Definition

The following definition was originally developed by the Ontario Ministry of the Environment in their Guidelines for the Handling and Disposal of Biomedical Waste, Final Draft, 1984. This definition was based on the Waste Classification Scheme found in the Canadian Standards Association, Handling of Waste Materials Within Health Care Facilities, 1981. A final document was published in 1986 by the Ontario Ministry of the Environment and is now entitled Guidelines for the Handling and Disposal of Biomedical Wastes from Health Care Facilities and Laboratories. The final document adopted a different definition for biomedical waste which reflects both the pathological and infectious nature of those wastes (Appendix 1).

Because the waste generation data in the present document are based on the original definition by the Ministry of the Environment, this definition has been maintained for the purpose of this report. The definitions do not differ significantly.

This report is limited to the management of Biomedical (Type A) Wastes only and excludes Institutional Wastes (Type B). In the text, Biomedical (Type A) Wastes will be designated as "Biomedical Wastes".

Biomedical Waste Type A

Class 1 Human anatomical waste (infectious and non-infectious) includes any part of the human body, tissues, blood or bodily fluids but excludes noninfectious blood and bodily fluids, extracted teeth, nail clippings and hair and the like.

Class 2 Animal anatomical waste includes all or any part of an animal, or tissue or bodily fluid of animal origin, that is infected or contaminated with an agent of a communicable disease or any agent, bacterium, virus, spore, cell, culture, medium or organism which is capable of causing disease or cell damage in humans or animals.

Class 3 Non-anatomical waste including:

a) Waste, from any source whatsoever:

(i) which is, or may be infected or contaminated with an agent of a communicable disease or any agent, bacterium, virus, spore, cell, culture, medium or organism which is capable of causing disease or cell damage in humans or animals, or which is:

(ii) a cytotoxic agent (antineoplastic) or equipment contaminated with a cytotoxic agent (antineoplastic) used in the treatment of cancer.

b) Laboratory wastes including, but not limited to: tissue, pus, blood, bodily fluids, feces, saliva, sputum, urine, exudates, microbiological and tissue cultures, vaccines, specimens and including specimen containers, waste containers, needles, syringes, and other laboratory equipment and materials contaminated with any of the above.

c) Any waste product of, or equipment used in: the production and use of recombinant DNA and hybrid or mutant organisms; animal virus research and synthesis; and animal cell research and production.

2 WASTE GENERATORS

In Canada the majority of biomedical waste results from the activities within the following sectors: Hospitals, Veterinary Services, Medical and other Health Laboratories, Research and Development Laboratories.

Hospitals

Hospitals are those health care institutions where patients are accommodated on the basis of medical need and provided with continuing medical care and supporting diagnostic and therapeutic services. General medical and surgical hospitals as well as specialty hospitals such as psychiatric hospitals, mental institutions, children hospitals and chronic disease hospitals are included in this sector. Table 2.1 summarizes the total bed set-up for use distributed by size groups and for each province and territory. A total of 1189 public and private hospitals were inventoried in 1985 with a total of 183 400 beds. Table 2.2 gives other health institution data for Canada.

Veterinary Services

Veterinary services include establishments of licensed practitioners primarily engaged in providing medical services for livestock and animals including household pets. Most of the 4000 veterinarians in Canada are in private (small) practice.

Medical and Other Health Laboratories

This sector is primarily engaged in providing professional analysis and diagnosis to the medical profession, to patients on prescription from a physician, in facilities specifically designed, staffed and equipped for such purposes. Included are blood banks, radiological, public health, medical (e.g., biological, cytological, mycological) facilities. These facilities receive specimens from other health care facilities (e.g., hospitals, physician's offices, nursing homes, etc.) and perform the required chemical, bacteriological or pathological analyses or examination on a systematic mass-produced basis.

No reliable data are available to indicate the total number of medical and other health laboratories in Canada.

Research and Development Laboratories

These establishments are primarily engaged in laboratory or other physical research and development on a contract or fee basis. The types of laboratory services

TABLE 2.1 BED SET UP FOR USE DISTRIBUTED BY SIZE GROUPS ADAPTED FROM CANADIAN HOSPITAL DIRECTORY, CHA, 1985

Provinces Territories	1-9		10-24		25-49		50-99		100-199		200-299		300-499		500+		TOTAL*	
	Inst.	Beds	Inst.	Beds	Inst.	Beds	Inst.	Beds	Inst.	Beds	Inst.	Beds	Inst.	Beds	Inst.	Beds	Inst.	Beds
Yukon and N.W.T.	-	-	-	-	2	59	2	122	-	-	-	-	-	-	-	-	4	181
B.C.	17	75	14	232	23	836	25	1 839	19	2 667	12	2 922	10	3 784	13	8 684	133	21 039
Alberta	-	-	15	244	60	1 979	45	2 863	16	2 112	9	2 031	6	2 196	9	8 106	160	19 531
Saskat.	8	64	69	1 065	31	1 000	12	813	4	561	7	1 673	5	1 898	1	548	137	7 622
Manitoba	7	54	37	612	16	540	6	415	8	941	1	252	6	2 153	4	3 229	85	8 196
Ontario	4	28	36	655	36	1 323	63	4 704	51	7 206	35	8 719	45	17 424	33	22 654	303	62 713
Quebec	1	7	13	213	39	1 465	39	2 742	54	7 328	36	8 888	35	13 136	20	14 531	237	48 310
N.B.	-	-	5	80	7	260	11	853	5	702	3	670	4	1 662	2	1 304	37	5 531
Nfld. and Labrador	-	-	10	187	11	386	4	273	3	41	3	730	3	1 152	1	525	35	3 665
N.S.	-	-	9	139	7	230	14	964	12	1 732	3	651	3	1 149	1	800	49	5 665
P.E.I.	-	-	2	46	1	33	3	163	2	353	-	-	1	352	-	-	9	947
TOTAL*	37	228	210	3 473	233	8 111	224	15 751	174	24 014	109	26 536	118	44 906	84	60 381	1 189	183 400

* Excludes HW, DVA, Industrial, Solicitor General Beds and Institutions.

TABLE 2.2 NUMBER OF GENERAL HEALTH CARE FACILITIES IN CANADA ADAPTED FROM CANADIAN HOSPITAL DIRECTORY, CHA, 1985

Province Territories	Nursing Stations	Outpatients Health Services Centers	Medical Services Branch	Medical Schools	Federal Institutions No.
Yukon	2		14		7
N.W.T.	40		8		
B.C.	4	10	33	1	1
Alberta	3	1	18	2	1
Saskatchewan		22	15	1	2
Manitoba	18	12	15	1	3
Ontario	11	30	22	5	3
Quebec	1	114	19	4	1
N.B.		16			
Nfld.	18			1	
N.S.		10		1	
P.E.I.					
Total	97	215	144	16	18

No. Health and Welfare, DVA, Industrial, Solicitor General

(excluding medical) or research activities include bacteriological, biological, chemical, electrical, food testing, soil testing and industrial testing.

Based on a 1978 survey there are a total of 177 establishments in Canada to provide these engineering and scientific laboratory services.

Other Sectors

Biomedical waste may also result from activities from these sectors:

- Medical clinics
- Physician's offices
- Veterinary schools
- Pharmaceutical industry
- Food, drug and cosmetic industries

3 WASTE GENERATION

Based on existing inventory data (Section 3.2) biomedical wastes count for less than one percent (1%) of the total hazardous wastes generated in Canada annually (Table 3.9)

Because they are the largest contributors of biomedical wastes in Canada and because they are the best documented among other generators, emphasis will be put on hospitals when characterizing and quantifying the wastes these activities generate.

3.1 Characteristics of Wastes

3.1.1 Hospitals.

i) Constituents

By definition, an important portion of biomedical waste is of a biological nature:

- Human anatomical, including any part of the human body, tissues, blood or bodily fluids; and
- Animal anatomical, including any part of an animal, or tissue or bodily fluid (as for research purposes only).

The other important portion is of a non-anatomical nature. Also by definition, a non-anatomical waste may be any hospital article contaminated or potentially contaminated (as from isolation areas) and usually not reusable. The following are commonly used disposable items (Block and Netherton (1977)) which have the potential to be contaminated:

Wards: Sheets, pillowcases, mattress covers, towels, washcloths, diapers, handkerchiefs, bath mats, bed pans, emesis basins, douche bags, urinals, soap dishes, bladder drainage systems, suction tubing, stomach tubes, cantor tubes, feeding tubes, dressing and suture removal trays, window curtains, oxygen tents, prepared enemas, enema administration bags and buckets, Foley catheter trays.

Nursing stations: Intravenous bags, measuring cups, prefilled syringes, unit dose medication.

Laboratories: Test tubes, sputum and stool containers, beakers, Petri dishes, pipettes, swabs, blood culture collection trays, coats, aprons.

Surgery: Drapes, gowns, gloves, aprons, booties, caps, masks, sponges, handbrush, forceps, scissors, scapels, keratome blades, syringes, needles, cannulae, catheters, vein strippers, sutures, anesthesia masks, mouthpieces, tubing, lumbar puncture

trays, myelogram trays, sterile irrigation trays, spinal or caudal anesthesia trays, exchange transfusion trays, venous pressure trays, manometer trays.

Food Service: Dishes, silverware, glasses, pitchers, trays, kitchen coverups.

Other: Inhalation therapy - masks, tubing reservoirs.
Nursery - prefilled nursers, baby bottles, bibs, diapers, blankets, washcloths, etc.
Renal dialysis - kiil envelope
Isolation - disposal room.

ii) Distribution

Data gathered in three hospitals in the Province of Manitoba (Canada (1984)) are summarized in Table 3.1. The overall waste distribution was consistent and was independent of the size of the hospitals. In research oriented hospitals, waste production from laboratories had the highest rate.

As summarized in Table 3.4, only 2-10% of the total hospital waste was of a biomedical nature. The biomedical waste portion mainly originated from the Ward (Maternity, Surgery, Intensive Care Unit), the Laboratories and the Support Services (Pharmacy) areas.

iii) Composition

The results of two different surveys are shown in Table 3.2. The first survey is a summary of the refuse composition from three Manitoba hospitals (Canada (1984)). The second survey was done in a British Columbia hospital (McCrae (1980)).

Both studies concluded that the major component of hospital waste was cellulosic solids (paper products). The other major components are plastics, kitchen wastes, non-combustibles (glass, metals), rubber and pathological wastes.

iv) Combustion Properties

Some combustion properties for hospital wastes are summarized in Table 3.3. Once again the size of the hospital does not significantly influence the results. The Lower Heating Value (LHV) is the amount of useful energy given off by the waste when all moisture has been removed.

TABLE 3.1 RELATIVE BREAKDOWN OF MAJOR WASTE PRODUCING AREAS FROM THREE DIFFERENT SIZE HOSPITALS (Canada 1984)

	Hospital 1 (500 Beds)	Hospital 2 (300 Beds)	Hospital 3 (100 Beds)
Support Services	16%	19%	14%
Labs	20%	14%	14%
Kitchen	26%	25%	30%
Wards	38%	42%	42%

TABLE 3.2 COMPOSITION OF TOTAL HOSPITAL WASTE MASS (percent by weight)

	Study 1 (HWC (1984))	Study 2 (McCrae (1980))
Cellulose Solids	50.0	45.1
Plastics		14.2
- Non halogenated	15.5	
- Halogenated	7.0	
Rubber	2.0	0.7
Non Combustible (glass, ceramics, metals, ash included)	9.9	20.4
Others (food wastes, pathological)	15.6	19.6
	100.0	100.0

TABLE 3.3 COMBUSTION PROPERTIES FOR HOSPITAL WASTE (Canada 1984)

	Hospital 1 (500 Beds)	Hospital 2 (300 Beds)	Hospital 3 (100 Beds)
Lower Heating Value (J/kg)	13 600	12 600	12 500
Moisture (%)	24.5	25.8	24.3
Ash (includes non-combustible) (%)	16.5	14.1	13.9

v) Volume and Density

Health and Welfare Canada (HWC 1984) has estimated the daily waste volume from three separate hospitals to be:

100 beds hospital: 3.5 m^3/day
300 beds hospital: 16 m^3/day
500 beds hospital: 54 m^3/day

The waste densities for the same hospitals were as follows:

100 beds hospital: 60.4 kg/m^3
300 beds hospital: 60.4 kg/m^3
500 beds hospital: 51.7 kg/m^3

3.1.2 Veterinary Services. The types of wastes typically generated by veterinary facilities include biological cultures, excised tissues, carcasses, bandages, vaccines and other drugs, and some organic solvents. Empty drug vials, syringes, needles and bedding material such as straw, sawdust, and paper contaminated with feces and urine may also be generated. Some of these wastes may contain pathogens with the potential for transmission of disease from animals to humans.

3.1.3 Medical and Other Health Laboratories. Biomedical wastes generated by these laboratories are typically:

- biological and contagious materials (cultures of pathological organisms, pathological tissue specimens, stool samples from infected individuals, etc.)
- clinical specimens for routine analysis procedures (blood, urine, vomit, etc.)

3.1.4 Research and Development Laboratories. Since laboratory services are rather heterogeneous, a variety of hazardous wastes are generated among which infectious biological wastes can be found.

3.2 Waste Generation Rate

No field surveys were actually done in preparation for this report. Therefore all attempts to quantify the total amount of biomedical waste in Canada rely on recent Canadian references where such data have been estimated or measured.

The variability in the results (especially for hospital wastes) is due primarily to the difference in the many definitions of biomedical (or otherwise called) wastes used in the surveys cited.

The total amount of biomedical wastes generated in Canada is in the order of 8 to 31 thousand tonnes per year (Table 3.9)

3.2.1 Hospitals. In 1973, Iglar et al. published a literature review indicating an increase in hospital waste generation from 7 pounds/bed/day in 1937 to 24 pounds/bed/day in 1969 in American human health care facilities. This increase in hospital waste generation is closely related to the trend of using disposable medical supplies.

According to the literature, American hospitals generate more waste on both "per bed" and "per patient" basis than Canadian hospitals. Table 3.4 indicates an average of 4.34 kg/bed/day in American hospitals compared to an average of 2.92 kg/bed/day in Canadian hospitals.

TABLE 3.4 SUMMARY OF GENERAL AND BIOMEDICAL HOSPITAL WASTE GENERATION RATE REFERENCED IN AMERICAN AND CANADIAN SOURCES (Summary of Appendix 3, 4 and 5)

Type of Waste	Sources	Generation Rate		
General	American	(a)	3.52	- 6.43 kg/patient/day
		(b)	4.28	- 4.39 kg/bed/day
	Canadian	(a)	3.34	- 3.83 kg/patient/day
		(b)		2.92 kg/bed/day
Biomedical - Type A	Canadian (1971-1985)	(a)	0.227	- 0.634 kg/patient/day
		(b)	0.196	- 0.408 kg/bed/day
			2	- 10% of total wastes
		mean (a)		0.43 kg/patient/day
		(b)		0.30 kg/bed/day
		(c)		6% of total wastes

With regard to biomedical wastes, Canadian hospitals generated between 227 and 634 g/patient or between 196 and 408 g/bed on a daily basis from 1971 to 1985 (Table 3.4). This implies a bed/patient ratio of between 1.16:1 and 1.55:1 or an occupancy rate of between 64 and 86%. In 1983-84, the percentage of occupancy in Canadian public hospitals was 83.32. Other sources cite the generation of biomedical wastes as being 2-10% of the total waste produced in a hospital.

Depending on the method of extrapolation (rate vs % of total wastes), the total quantity of biomedical wastes produced annually in Canadian hospitals varies from 4000 to 27 000 tonnes (Table 3.5).

TABLE 3.5 DAILY AND ANNUAL GENERATION OF BIOMEDICAL WASTE IN CANADIAN HOSPITALS (extrapolation from Tables 2.1 and 3.1)

	Generation			
	Daily (kg)		Annually (tonnes)	
Generators	A	B	A	B
Yukon & N.W.T.	36 - 74	11 - 53	13 - 27	4 - 19
B.C.	4 124 - 8 584	1 229 - 6 143	1 505 - 3 133	449 - 2 242
Alberta	3 828 - 7 969	1 141 - 5 703	1 397 - 2 909	416 - 2 082
Saskatchewan	1 494 - 3 110	445 - 2 226	545 - 1 135	162 - 812
Manitoba	1 606 - 3 344	479 - 2 393	586 - 1 221	175 - 873
Ontario	12 292 - 25 587	3 662 - 18 312	4 487 - 9 339	1 337 - 6 683
Quebec	9 469 - 19 710	2 821 - 14 107	3 456 - 7 194	1 030 - 5 149
N.B.	1 084 - 2 257	323 - 1 615	396 - 824	118 - 589
Nfld.	718 - 1 495	214 - 1 070	262 - 546	78 - 391
N.S.	1 110 - 2 311	331 - 1 654	405 - 844	121 - 604
P.E.I.	186 - 386	55 - 277	68 - 141	20 - 101
Canada TOTAL:	35 946 - 74 827	10 711 - 53 553	13 120 - 27 312	3 910 - 19 547

Method A: from daily rate calculation (0.196-0.408 kg/bed/day)
B: from percentage calculation (2-10% x (2.92 kg/bed/day)

The major factor influencing the accuracy of the quantity of biomedical waste generated is the definition used. Each hospital in Canada probably has its own interpretation of what constitutes a biomedical waste. Hospital wastes are often managed based on their destination rather than their nature. Hospital refuse would tend to lose its hazardous waste "tag" when an incinerator is not accessible.

Other important factors in influencing the recorded quantities are:

- Size of the hospital: more services generally mean more wastes;
- Quantities of disposables: the extent to which disposables are used increases the final waste load;
- Non-standardization: some reports include the newborn bassinets and the newborn census; some reports are based on the number of employees rather than the number of beds or patients;
- Type of hospitals: teaching and research hospitals are known to generate more waste.

3.2.2 Other Sources. The generation rates for the following sources have been taken from the report Characterization of Hazardous Wastes from Small Quantity Waste Generators (Non-Manufacturing) - A Preliminary Review, W. Jan, Environmental Protection Service, Environment Canada, 1984. This E.P.S. study relied primarily on the U.S. technical document (USEPA (1979)) which uses factors for calculating the amount of waste generated within various small volume hazardous waste generators. The similiarity between Canadian and American small generators is assumed due to the fact that the living style and economic index in both countries are comparable.

It is important to note that the generation factors developed in the American document represent all the hazardous wastes generated from the sector rather than just the biomedical portion of the refuse. Therefore, a maximum of 50% of the total from each sector will be assumed to be of a biomedical nature.

3.2.2.1 Veterinary services. Based on an average generation rate of 52 kg/month/veterinarian, the amount of hazardous waste generated is estimated at 2435 tonnes/year. The amount of biomedical wastes is in the order of 1200 tonnes/year (Table 3.6).

3.2.2.2 Medical and other health laboratories. Based on an average generation rate of 6.5 kg/month/employee, the amount of hazardous wastes generated from the medical laboratories is estimated at 3006 tonnes/year. An estimated 1500 tonnes/year would be of biomedical nature (Table 3.7).

TABLE 3.6 VETERINARY SERVICES (Generation Factor 52 kg/month/veterinarian)

Province	No. of Veterinarians	Quantity of Hazardous Wastes Generated (tonnes/year)
Newfoundland	21	13
Prince Edward Island	33	21
Nova Scotia	103	64
New Brunswick	84	52
Quebec	434	271
Ontario	1788	1116
Manitoba	179	112
Saskatchewan	297	185
Alberta	535	334
British Columbia	427	266
Northwest Territories (including Yukon)	2	1
Canada	3903	2435
Quantity of Biomedical Waste	(50%)	1200

3.2.2.3 Research and development laboratories. Based on an average rate of 1545 kg/month per establishment, quantities of hazardous wastes generated from research and development laboratories are estimated at 3282 tonnes/year, half of which would be biomedical wastes: 1600 tonnes/year (Table 3.8).

TABLE 3.7 MEDICAL AND OTHER HEALTH LABORATORIES (Generation Factor 6.2 kg/month/employee)

Province	No. of Employees	Quantity of Hazardous Wastes Generated (tonnes/year)
Newfoundland	810	63
Prince Edward Island	126	10
Nova Scotia	1 436	112
New Brunswick	869	68
Quebec	9 432	736
Ontario	14 378	1 121
Manitoba	1 863	145
Saskatchewan	1 593	124
Alberta	3 866	302
British Columbia	4 136	323
Northwest Territories	32	5
Yukon	5	Less than 1
Canada	38 546	3 006
Quantity of Biomedical Wastes	(50%)	1 500

TABLE 3.8 RESEARCH AND DEVELOPMENT LABORATORIES (Generation Factor 1545 kg/month/establishment)

Province	No. of Establishments	Quantity of Hazardous Wastes Generated (tonnes/year)
Newfoundland	2	37
Prince Edward Island	--	--
Nova Scotia	5	93
New Brunswick	3	56
Quebec	42	779
Ontario	58	1075
Manitoba	4	74
Saskatchewan	5	93

TABLE 3.8 RESEARCH AND DEVELOPMENT LABORATORIES (Generation Factor 1545 kg/month/establishment) (Cont'd)

Province	No. of Establishments	Quantity of Hazardous Wastes Generated (tonnes/year)
Alberta	33	612
British Columbia	25	463
Yukon	--	--
Northwest Territories	--	--
Canada	177	3282
Quantity of Biomedical Wastes	(50%)	1600

TABLE 3.9 BIOMEDICAL WASTE GENERATION IN CANADA

Sources	Quantities (tonnes/year)
Hospitals	4000 - 27 000
Others:	
- Veterinary Services	1200
- Medical and Other Health Laboratories	1500
- Research and Development Laboratories	1600
Canada (Biomedical)	8300 - 31 300
Hazardous Wastes in Canada (Gore and Storrie (1982))	3 280 000
% of total	0.0025 - 0.0095

4 CURRENT MANAGEMENT PRACTICES

This section summarizes the current management practices within Canadian Hospitals and Veterinary Services.

4.1 Hospitals

The management of biomedical wastes in Ontario was assessed in 1984. As part of an Interministry Task Force on Biomedical Waste (Section 6. 1.6), the Health Care Occupational Health and Safety Association, a division of the Ontario Hospital Association, established a focus group to assist in the development of a meaningful guideline for use by health care facilities.

Because of the lack of information on the trends and practices regarding the handling and disposal of biomedical wastes, a survey was developed and distributed to all public hospitals in Ontario. The highlights of the results of this survey are following:

1) The average amount of biomedical wastes is approximately 152 kilograms/day/hospital (based on quantities reported by 75 hospitals).
2) The estimated cost of disposal is $54.40/kilogram/day/hospital (based on responses by 42 facilities).
3) Standardization is lacking in terms of container types and colour coding.
4) Incineration is the preferred method of ultimate disposal even if only 96 out of 165 hospitals surveyed had operating incinerators; the survey shows that hospitals share their incinerators with other community groups and agencies.

The Quebec situation with regard to biomedical wastes was reviewed in 1986 by the Quebec Department of the Environment. Various parties were interviewed (producers, transporters, disposal facilities) and the results of this study are to become public in 1987. The province is also drafting a definition for biomedical waste.

In Newfoundland and Labrador, biomedical waste management is largely left to the generators. In general, wastes are segregated as to their disposal requirements. The majority of hospitals have on-site incinerators which are used to dispose of most of the biomedical anatomical wastes. Non-anatomical wastes are bagged and sterilized; or rendered unusable and disposed of through on-site incineration or landfilling.

Any landfilling of biomedical wastes is co-ordinated through the Newfoundland Department of the Environment.

In Prince Edward Island the disposal methods for hospital wastes are approved as part of the accreditation procedure (Community Hygiene). Although aware of the CSA Standard on the Handling of Waste Materials Within Health Care Facilities, the latter is not followed in P.E.I. Two of the largest urban hospitals have their own waste disposal procedures and an on-site incinerator.

Biomedical waste management is the responsibility of the generator in Saskatchewan. Where available, incinerators are utilized for most biomedical wastes of concern. Disposal to sanitary sewers and landfill are other accepted disposal methods.

The Manitoba hospitals are using the CSA Standard Z317.10-M1981 as a guideline for handling biomedical wastes. On-site incinerators are used for the disposal of those wastes; municipal landfills and sanitary sewers are other accepted methods.

Table 4.1 presents the current management of biomedical waste for Alberta, New Brunswick and Nova Scotia hospitals. The detailed information is summarized in Appendix 6, 7 and 8.

Alberta hospitals stress the double-bagging of contaminated waste and the segregation of sharps which reflects the CSA Standard. Urban hospitals are lacking in sterilizing these same wastes but are favouring incineration.

Tables 4.2 and 4.3 define the extent to which each treatment or disposal technology is used in two New Brunswick and Nova Scotia general hospitals (New Brunswick and Nova Scotia were the only two provinces to provide this information). It is definitely not possible to portray the management of biomedical wastes in Canada from only these two institutions. However, these data suffice to conclude that hospital administrators have different approaches dealing with biomedical wastes (which may or may not be environmentally adequate). From the above two tables, biomedical wastes are disposed in the following manners:

	Nova Scotia	New Brunswick
Sewage System (treated or not):	40%	42%
Incineration:	2%	25%
Landfill (treated or not):	58%	33%

4.2 Veterinary Services

Most of the information collected on the management of biomedical waste from veterinary services is tabulated in Table 4.4. Despite good information from specific generators, the overall situation for waste management from these services

Table 4.1 Management of Biomedical Waste (Type A) in Canadian Hospitals

PROVINCE	CLASS	SOURCE ITEM	HANDLING							TREATMENT					DISPOSAL					
			Segregation	Bagged	Double-Bagged	Collection on a special routine or containers	Gravity Chutes	Manual Carts	No special mention of contaminated waste	Compacted	Rendered Unusable	Chemically Neutralized	AUTOCLAVED On-site (on) Off-site (off)	No Treatment	Sewer	Local Pump	INCINERATION On-site (on) Off-site (off) Not specified (ns)	Ash Compacted	Landfill	Method not specified
ALBERTA 24 URBAN HOSPITALS (% OF H.)		Sharps	(46)			(46)														
		Combustible	(54)														(50) (ns)			
		Dressings & Biological											(4) (on)						(4)	
		Contaminated Wastes			(54)		(38)	(38)						(42)			(54) (ns)		(42)	
		All Wastes																	(33)	
126 SMALL COMMUNITY HOSPITALS (% OF H.)		Contaminated Wastes			(69)				(20)				(2)							
		Needles & Sharps				(9)														
NEW BRUNSWICK	1	ANATOMICAL NON-INFECTIOUS Path. Dept. or Lab		X		X											X			
		Operating Rooms				X										X	X (off)			
		ANATOMICAL INFECTIOUS Operating Rooms / Wards		X											X		X			
	3	Contaminated Equipment / Nursing Care		X									X							
						X					X						X (on)		X	
		Specimens from Microbiology Labs													X					
																	X (on)			
												X	X				X (on)			
		Antineo-Plastics										X	X						X	
																	X			
				X													X			

PROVINCE	CLASS	SOURCE / ITEM	HANDLING							TREATMENT					DISPOSAL					
			Segregation	Bagged	Double-Bagged	Collection on a special routine or containers	Gravity Chutes	Manual Carts	No special mention of contaminated waste	Compacted	Rendered Unusable	Chemically Neutralized	AUTOCLAVED On-site (on) Off-site (off)	No Treatment	Sewer	Local Pump	INCINERATION On-site (on) Off-site (off) Not specified (ns)	Ash Compacted	Landfill	Method not specified
NOVA SCOTIA	1	Pathology Department / Operating Rooms				X				X							X	X	X	
		Anatomical Non-contaminated		X															X	
																	X			
						X											X (on)	X	X	
																			X	
																	X (off)			
	3	Contaminated Equipment / Nursing Care											X				X (off)	X	X	
				X													X (on)			
											X								X	
															X					
																			X	
		Sharps				X					X						X (on)		X	
										X		X							X	
													X (off)							
													X				X (on)			

TABLE 4.2 TREATMENT AND DISPOSAL PRACTICE OF BIOMEDICAL WASTES IN A 450-BED NEW BRUNSWICK PUBLIC GENERAL HOSPITAL (New Brunswick (1985))

Treatment and Disposal Route	Percentage of Total Weight) (LT: less than; GT: greater than)
Chemical treatment - Sewage System	3%
Thermal Sterilization - Landfill	LT 1%
Sewage System	39%
Chemical treatment - Thermal Sterilization Sewage System	LT 1%
Incineration - Landfill	12%
Thermal Sterilization - Incinerator - Residues to Landfill	GT 13%
Landfill	33%

TABLE 4.3 TREATMENT AND DISPOSAL PRACTICE OF BIOMEDICAL WASTES IN A 200-BED NOVA SCOTIA PUBLIC GENERAL HOSPITAL (Nova Scotia 1985))

Treatment and Disposal Route	Percentage of Total Weight) (LT: less than)
Chemical treatment - Sewage System	40%
Thermal Sterilization - Landfill	30%
Thermal Sterilization - Sewage System	LT 1%
Chemical Treatment - Incineration - Residue to Landfill	2%
Chemical Treatment - Landfill	28%

remains incomplete. However, it is clear that incineration is the preferred method for ultimate disposal.

The Western College of Veterinary Medicine in Saskatoon collects a total of 1400 kg/day of pathological waste from a variety of sources on the University of Saskatchewan campus. These wastes are burned on site in an approved and licensed incinerator.

Table 4.4 Management of Biomedical Waste in Canadian Veterinary Services

PROVINCE OF ORIGIN	SOURCE	CLASS / DESCRIPTION OF WASTE	HANDLING			TREATMENT					DISPOSAL		
			Double-Bagged	Boxed	Collected as needed	Frozen	Heated	Chemical	Autoclaved	Rendering plant	Sanitary Sewer	Incinerated	Landfilled
SASKATCHEWAN Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon	Veterinary hospitals, teaching and research labs	All pathological wastes										X	
		Large carcasses & bedding			X								
		Smaller carcasses & contaminated material	X	X								X	
MANITOBA		Most wastes											X
		Rest of wastes										X	
ONTARIO Ontario Veterinary College, University of Guelph		2										X	
		Isolation wastes					X				X		
		3							X				
												X	
NEWFOUNDLAND & LABRADOR Animal Health Division, Dept. of Rural, Agricultural and Northern Development	Veterinary Diagnostic Laboratory	All wastes										X (on-site)	
	Swine breeding Stations	Diseased animals										X (on-site)	
	Areas of province without incineration capabilities	Dead animals											X (approved sites)
PRINCE EDWARD ISLAND	Provincial Diagnostic Laboratories Department of Agriculture, Charlottetown	Any material that poses a potential problem										X	
		Dead animals				X				X			
	Private Veterinary Clinics	Some of the dead animals								X			
FEDERAL Animal Disease Research Institute, Agriculture Canada, Ottawa, Ontario	Eight (8) Laboratory facilities	2 SOLID										X (on-site)	
		LIQUID						X					
							X				X		
		3 LIQUID (infectious agents liquids, plastics)							X		X		
		SOLID							X			X	
		Blood and sera from uninfected animals									X		

The Ontario Veterinary College on the University of Guelph campus treats its liquid animal isolation waste by heat sterilization. The waste is stored in storage tanks which are heated to 80°C for 30 minutes and then cooled before passing to sewage.

The Quebec Department of the Environment is currently drafting a definition for biomedical waste as well as a policy that will guide the management of these wastes from any sources including veterinary facilities.

In Newfoundland and Labrador, the Department of Rural Agricultural and Northern Development operates incinerators for in-house use but these can be made available to the public through private veterinary clinics. In other areas where incinerators are not accessible, dead animals are disposed of in approved sanitary landfills.

5 BEST AVAILABLE MANAGEMENT TECHNOLOGIES

This chapter reviews the different biomedical waste management technologies described in the literature. The suitability of each technology for specific types of waste is discussed wherever options are possible. Available information was not sufficient to establish the extent to which each technology is applied or used in Canada.

5.1 Storage

Within the management of biomedical wastes, storage consists of three stages: 1) primary; 2) waste-holding; 3) pre-disposal.

5.1.1 Primary Storage. This first stage is usually at the point of origin and involves the use of small receptacles. The advent of plastics on the market has been a major breakthrough, in terms of primary storage methods. The use of waste baskets, laundry hampers, carts, buckets (Bond et al. (1973)) or special holders for hanging autoclavable bags for laboratories (WHO (1983)) has been developed as primary storage containers. The use of the above is completed by lining them with plastic bags for ease of collection, reduction of cleaning frequency and time, and elimination of the risks of cross-contamination. The ideal plastic bag as primary storage container is a compromise between resistance to internal or external mechanical damage and ease of thermal destruction. The segregation of wastes can be simplified at the primary storage stage by using colour coded bags. Double-bagging is recommended for all biomedical wastes. The following requirements have been recommended:

- outer bag may be less than 0.04 mm (1.5 mils) but not less than 0.032 mm (1.25 mils).
- inner bag for pathological waste and institutional waste shall be at least 0.051 mm (2 mils).

5.1.2 Waste Holding and Pre-Disposal. Most biomedical wastes (either infectious or non-infectious) by-pass the waste-holding stage and go directly to pre-disposal on a special collection or on an "as necessary" basis. All other biomedical wastes (non-infectious or previously sterilized) are stored temporarily in a waste-holding area, located usually in a central section of a facility floor or department. The wastes are then routed to a pre-disposal area usually receiving all the segregated wastes from the facility. Pre-disposal storage areas are also found at off-site treatment facilities.

Waste-holding areas and pre-disposal areas should meet the following requirements if used to store Biomedical Type A, Class 1 Wastes (CSA (1981)):

- Should be located inside the facility.
- Should have mechanical ventilation providing six (6) air changes per hour.
- Relative air pressure should be negative with respect to the adjacent areas; exhaust vents for this system should discharge to the outside environment and should not be near the facility's heating or air condition systems. Filtration through High Efficiency Particulate Air (HEPA) filters might be necessary to pick up any contaminants.
- Should be totally enclosed and separated from supply rooms or food preparation areas.
- Temperature should be maintained at or below 4°C.
- All waste storage areas should meet the requirements of the locally prevailing Building Code.

5.2 Transportation

In this section, the various methods available for transporting biomedical wastes on-site and off-site to an ultimate disposal site are discussed.

5.2.1 Handling. In the context of health care facilities, "handling" is the link between packaging, storage and transport (WHO (1983)). This aspect of management deals with the closure of bags or containers and their manipulation to a transportation mean or a treatment unit.

The handling aspect can only be improved through better safety equipment and better education of the handlers. The technology has yet been unable to completely mechanize waste handling in hospitals.

5.2.2 On-Site Transportation. In-house transportation might generally be divided into two stages:

1. Transportation of wastes from primary storage to waste-holding areas;
2. Transportation of wastes from waste-holding areas to one or more pre-disposal areas.

The first stage is usually managed manually with the help of push or hand carts.

The second stage offers a variety of alternatives, depending on the nature of the wastes. These alternatives will be reviewed and their suitability for biomedical wastes will be assessed more specifically. The following seem to be the possibilities that waste handling suppliers are still offering to the health care industry (Bond et al. (1973), Stachiw (1976), Inglar and Bond (1973)):

i) Manual System
ii) Gravity Chute - Manual System
iii) Gravity Chute and Pneumatic Tube System (P.T.S) or all P.T.S.
iv) Self Propelled Carts
v) Monorail Conveyor and Overhand Conveyor
vi) Conveyor Belt

i) Manual System

This system employs a fleet of the traditional hand carts in a predetermined itinerary around the facility's floors. The worker pushing the cart transfers the wastes from the waste-holding areas into the vehicle until it is full. The cart is then wheeled to the central storage area (or pre-disposal) where all the waste bags are unloaded. This process is repeated until all the waste-holding areas have been emptied. CSA recommends a daily cleaning and disinfecting schedule for the waste-management carts.

Problems associated with this method can be solved through careful planning of the routes, training of the personnel, adequate sizing and construction of the carts.

Advantages: very flexible; can be adapted to any type and quantity of wastes.

Disadvantages: slow; adds to traffic congestion; potential for contaminating the facility environment.

ii) Gravity Chute - Manual System

A gravity chute is a vertical tube, square or cylinder, usually made of stainless steel or aluminum. They generally have a mechanical exhaust, a sanitizing unit and a fire prevention system.

The tube has an access door on each floor located where the bags from the waste-holding areas are to be loaded.

Backdraft and piston effect are prevented by having an interlockable door system and by maintaining a slight negative pressure within the tube.

The wastes accumulate in a cart placed at the bottom of the chute. Once filled, this cart is replaced with an empty one, moved to the pre-disposal area, unloaded manually and returned to the chute discharging point.

Anatomical and heavily contaminated wastes are not suitable for this type of transportation.

Good design and construction of the chutes; proper operation and utilization; and the segregation and proper enclosure of the wastes should eliminate the safety hazards linked with this means of biomedical waste transportation.

Advantages: accelerates collection rate; alleviates traffic in elevators and corridors.

Disadvantages: adds a handling step at the chute access door and sometimes at the chute exit; maintenance operations; fire hazards.

iii) Gravity Chute Pneumatic Tube System (P.T.S.) or all P.T.S.

The pneumatic tube system (P.T.S.) is a network of vertical and horizontal tubes. A forced air stream, resulting from the action of high velocity suction blowers, carries the loads as they are introduced into the system and are routed, depending on their nature. A positive pressure system also exists. The air stream is filtered before being exhausted and the containers are collected in a hopper.

Access to the chute is provided by two doors: an outer door into which waste is dumped and an inner door which provides closure between the charging station and the tube when the outer door is open. The system is programmed so that only one load (or one type of waste) can enter at a time.

The World Health Organisation (WHO) recognizes that "pneumatic pipeline transport systems are used for waste movement in some modern hospitals". But WHO also recommends avoiding the use of this system for " pathological and infectious waste". WHO's definition of pathological waste is equivalent to Type A, Class 1, defined in this document; infectious waste is defined as Type A, Class 3 items a)(i) and b). This permits very limited application of P.T.S. in the management of biomedical waste Type A (some sterilized Type 3 wastes could be an application).

Advantages: allows for transportation of waste to almost any location in the building; can be installed in existing facilities; capable of horizontal and vertical movement; reduces labor costs considerably.

Disadvantages: frequent mechanical failures; high maintenance; limitation in tube sizing; not recommended for Biomedical Type A, Class 1 and some Class 3 wastes,

radiological, toxic chemical and flammable solvent wastes; major capital investment.

iv) Self-Propelled Carts

These vehicles are propelled with rechargeable power units and are capable of horizontal and vertical movements. The horizontal directions are controlled by a network of wires, concealed in the floor, and interpreted electronically by the cart. Vertically, the cart is transported by special elevators, again, sensitive to electronic signals emitted by the cart. The carts are dispatched from the central storage area where their programmed destinations can be dialed by an operator. Stops at waste-holding areas are also programmed so that maintenance personnel can load the carts with the accumulated wastes.

Features such as manual controls for removing the cart from its original path and an immediate stop when in interference with an obstacle favor its use in buildings like hospitals.

Soiled material can be stored in individual bins or on a separate cart for better segregation and minimizing cross contamination. Also, separate elevators should be used for upward and downward movement to minimize the risks of cross contamination.

Although this system is somewhat similar to the manual system, unattended transportation of biomedical wastes remains questionable.

Advantages: decreases the labour requirement.

Disadvantages: dependent on power modules which are expensive; the movements of the cart may be delayed if an obstacle happens to be in its path; high maintenance and planning.

v) Monorail Conveyor and Overhand Conveyor

The monorail conveyor system is a series of motorized transporters suspended from a monorail track and typically, operates within its own confinement, or shaft, except at the loading and unloading stations. Itineraries can be either programmed or improvised upon request.

The overhead chain conveyor system uses the overhead tracks for the motive power to move the transporters.

These systems allow for vertical and horizontal movements. Another feature is the bottom access door on the carts allowing for an easy discharge of the waste over the

final storage area. Both systems can be cleaned and sterilized through a washer/sterilizer unit installed on-line. Sterilized wastes may be transported, providing that access to the shaft is maintained.

Advantages: automatic unloading; carts less expensive than other automatic handling systems.

Disadvantages: implementation in existing facilities; improper uses; needs an extensive preventive maintenance program.

vi) Conveyor Belts

Boxes or bags containing wastes are moved vertically or horizontally on roller conveyors powered by an endlesss belt, continuous chain, or by a series of progressive chains. Boxes can be routed through a magnetic reading (such as a bar code system). Like the other systems, access doors strategically located alleviate the circulation congestion.

Again, this system is not recommended for unsterilized wastes or anatomical wastes.

Advantage: allow for movements throughout the facility.

Disadvantages: multi-handling (loading/unloading of container boxes); many conveyors needed; thus, spacing problems.

Table 5.1 presents a comparison among the different in-house transportation options discussed above.

5.2.3 Off-Site Transportation. Off-site transportation is used to move waste to its ultimate disposal site, such as a landfill, or it might be needed when using an off-site treatment facility (centralised sterilizing facility, incinerator or transfer station).

Waste transportation vehicles should be specially designed for biomedical waste use. Adaptation is made to reflect guidelines and regulations, such as the CSA Standard and the Transportation of Dangerous Goods Regulations, Transport Canada, or its equivalent provincial regulation (exemptions under TDGA are discussed in section 6). The CSA recommendations are as follows:

- Transportation vehicles for biomedical wastes (Class 1 and 2) should be clean, insulated and refrigerated.
- Transportation vehicles for non-anatomical biomedical wastes (Class 3) may not need to be refrigerated or insulated depending on the acceptance of sterilized waste as regular garbage by the local authority.

TABLE 5.1 ADVANTAGES AND DISADVANTAGES OF WASTE TRANSPORTATION SYSTEMS

Advantages		Disadvantages
	MANUAL	
Very flexible; can be adapted to any type and quantity of wastes Low capital cost		Slow Adds to traffic congestion Potential for contaminating the facility's environment High labor cost
	GRAVITY CHUTE	
Accelerates collection rate Alleviates circulation in facility Low capital cost		Adds a handling step at the chute access door and even at its exit Fire and blocking hazard Not advisable for anatomical wastes and sharps
	PNEUMATIC TUBE	
Flexible Can be installed in existing facilities Capable of horizontal and vertical movements Low labor costs		High maintenance Limitation in tubing size Not recommended for anatomical wastes and sharps, radiological, toxic chemical and flammable solvent wastes High capital and maintenance costs Requires back-up system
	AUTOMATIC CARTS	
Decreases labor costs Capable of horizontal and vertical movements Can be used for all types of wastes		Depends on expensive power modules Movements of the carts may be delayed by obstacles High maintenance and planning Requires back-up system High capital costs
	MONORAIL OVERHEAD CONVEYOR	
Automatic unloading Carts less expensive than other automatic systems Low labor costs		Implementation in existing facilities High maintenance Improper uses Needs an extensive preventive program High capital costs Requires back-up system Not suitable for contaminated material
Allows for horizontal and vertical movements	CONVEYOR BELT	Multi-handling (loading/unloading of container boxes) Many conveyors needed, thus, spacing restrictions Not suitable for contaminated material

CSA also recommends that the vehicles should be designed for ease of cleaning, should be disinfected at the conclusion of each day's work, and should be stored in a restricted and enclosed area. This area should prevent people or vectors from accidental contact with any pathogens and prevent the weathering process (ie. wind, rain) from carrying any contaminated particles (ie. dust).

5.3 Treatment Technologies

5.3.1 General. The U.S. Environmental Protection Agency (1986) defines the treatment of infectious waste as the change of its biological character by any method, technique or process so as to render the waste non-hazardous and safe for disposal. US EPA also identifies three types of treatment generally accepted for infectious waste treatment:

1) heat treatment: steam and dry heat sterilization
2) chemical treatment: gas/vapor and chemical sterilization
3) irradiation

Each of the preceeding techniques have some standardized operational procedures. A standard load has to be developed in accordance with the specifications of the equipment and the waste variables such as type, density, moisture content, packaging, size and loading configuration. Operating conditions are then set with the ultimate goal being the sterilization of the waste load. This sterile criterion is established through monitoring by using biological indicators such as a commercial preparation of bacterial spores. These microorganisms are known for their resistance to treatment methods. Consequently, if a given treatment process can achieve the destruction of bacterial spores added to a waste load, it is assumed that sterilization will be complete for the entire load. A periodic monitoring program is then established to detect any faults or shortcomings in the process.

Operating techniques of any infectious waste treatment method can be optimized through proper personnel training and monitoring schedules.

5.3.2 Steam Sterilization (Brenniman et al. (1984), US EPA (1982)). There are two types of steam sterilizers or autoclaves: 1) the gravity displacement type, and 2) the pre-vacuum type. The gravity displacement type forces out the air enclosed in the treatment chamber by injecting steam whereas the pre-vacuum type pulls a vacuum to remove the enclosed air and then steam is introduced.

The temperature is a function of the steam pressure with the principal variable being the length of the cycle. The gravity displacement type and vacuum type will typically operate at 121°C and 132°C, and under 117-124 k PA and 186-220 k Pa of saturated steam. The length of the cycle is dictated by the predetermined kill time for the appropriate microorganisms.

Factors to consider when developing standard loads are:

- type of waste
- packaging material (ie. sterilizable vs. non-sterilizable bags)
- integrity of the package (ie. closed or open containers)
- type of containers (ie. placing the bag into a shallow metal pan)
- addition of water to the container or the waste (addition of water to some wastes might facilitate the heating process)
- volume and configuration of the load (ie. smaller loads might be sterilized easier).

The standard procedures should be posted near the sterilizer for easy reference when operating the equipment.

Advantages: versatility of the type of wastes that can be treated; versatility and availability of this equipment on the market.

Disadvantages: different conditions of treatment exist for different types of waste; difficulty of assessing the extent of sterilization; handling problems if bags are handled roughly or punctured; autoclaves are not available in all departments of the institution, therefore, possibility of spreading pathogens when handled.

5.3.3 Dry Heat Sterilization. This treatment is the application of heat without any steam and is used for large volume of liquid wastes, solid wastes, and contaminated equipment.

Two processes are used in the heat sterilization of liquid wastes: 1) batch, and 2) continuous treatment process. The batch process consists of heating the liquid in its container to sterilization temperature and allowing proper exposure time. The liquid is then discharged. The continuous treatment process consists of a tubing system maintaining the circulating liquid waste at the predetermined treatment temperature.

Biomedical solid wastes can be treated with ovens and hot air sterilizers. Factors to consider when determining the standard loads are:

- type of waste (the heat conductivity is a characteristic of the material);
- load volume (overloading may interfere with the sterilization process);

- packaging material and container (the type of material will affect the conductivity and should not melt);
- loading configuration (the wastes should be loaded in such a way to permit free circulation of the heated air throughout the chamber).

Advantages: may have applications where other sterilizers do not accept large quantities of liquid wastes.

Disadvantages: costly and time consuming for contaminated equipment; longer exposure and at a higher temperature than steam sterilization.

5.3.4 Gas/Vapor Sterilization. This treatment process is similar to steam sterilization except for the injection of a gaseous chemical instead of steam. Ethylene oxide and formaldehyde are two chemicals commonly used.

The Environmental Protection Agency (1986) and Brenniman et al. (1984) have documented health problems associated with exposure to ethylene oxide. This alternative is only recommended when no others are available. Although this chemical penetrates polyethylene, paper and muslin packaging and kills all known microorganisms, it is not usually used to sterilize wastes but rather reusable equipment and supplies, due to the high cost of the chemical.

Formaldehyde also presents health risks (EPA (1982), Brenniman et al. (1984)) and is used for sterilizing wastes, equipment, ventilation systems and spaces.

Standard loads are designated in conjunction with:

- type of waste (porous vs smooth surface)
- packaging material (should be permeable to sterilizing agent)
- load volume
- loading configuration

Advantages: can sterilize equipment and supplies and wastes that could not be sterilized otherwise.

Disadvantages: Expensive; health risk if not operated properly.

5.3.5 Chemical Disinfection (EPA (1986)). A disinfectant is defined as a "chemical agent that destroys microorganisms but not bacterial spores" (Lapedes (1978)). In the context of health care facilities, chemical disinfection is generally associated with the disinfection of hospital supplies, equipment or surfaces but is encountered frequently in the treatment of liquid waste prior to elimination into the sewage system. This practice is both recommended and used in Canada (section 4).

The chemicals used in disinfection are generally acids, alkalies, aldehydes, alcohols, amines, halogens, heavy metal salts, ketones, quaternary ammonium compounds, phenolic compounds and hydrogen peroxide. For the treatment of infectious liquids specifically, sodium hypochlorite and formaldehyde are frequently used.

Because this technique is simply disinfecting rather than sterilizing, and because of the many factors influencing the development of standard operating procedures (ie. type of contaminating organisms; degree of contamination; type; concentration and quantity of chemical; contact time), chemical sterilization can only be assumed reliable in special circumstances and for certain wastes.

5.3.6 Irradiaton (EPA (1982), EPA (1986), Reavely and Warwick (1971)). Ultraviolet ray, gamma ray and accelerated electron types of radiation have found application in the sterilization of solid and liquid wastes, medical supplies and food preservation (EPA (1982)).

Ultraviolet radiation is limited to surface treatment since it cannot penetrate material for more than a few centimeters. Consequently it is usually used to treat packaged material. High electrical energy and shielding are required during this process.

Gamma radiation is usually derived from the radioisotope cobalt-60 produced in nuclear reactors. Gamma rays penetrate to a depth of several metres and therefore have application in waste treatment. An automated transport system is used to expose the waste load or package to the emitting source. Reavely and Warwick (1971) discussed extensively the cost and feasibility of adapting a cobalt-60 irradiator (designed for research purposes) as a hospital infectious waste sterilizer. At that time, a dosage of 2.5 Megarads (Mrads) was recognized internationally as acceptable for sterilizing disposable surgical supplies (1 Megarad = 10^8 ergs of gamma energy absorbed per gram of target material). A later study suggested the use of 1 Mrad would be sufficient for killing all known microorganisms.

Reavely and Warwick concluded that, although feasible, a gamma irradiation sterilizer would not have been cost effective at that time (Table 5.2) even considering treating infectious wastes from all London hospitals.

Advantage: the capability to treat any kind of infectious wastes.

Disadvantage: the cost.

5.3.7 Reduction, Recycling and Reuse. The potential for reducing, recycling and reusing biomedical wastes is generally limited.

TABLE 5.2 COST PER CUBIC METER OF WASTE FOR THREE STERILIZATION PROCESSES (Reavely and Warwick (1971))

Treatment Process	Cost/m^3 (in 1970 Canadian Dollars)
Steam Sterilization	2.70
Gas Sterilization (used to treat reusable items)	21.00
Gamma Irradiation	
113 000 Ci source	5.40 (no.)
900 000 Ci source	10.50

no. Price includes packaging cost but excludes depreciation costs

For some wastes (ie. cytotoxic agents), reduction is possible through good planning of the actual needs of the hospital. But for the majority of biomedical wastes, this is not feasible. If incineration is perceived as a treatment method, reduction of up to 95% can be achieved prior to final disposal (EPA (1986)).

Rendering plants are commonly used to recover grease and fat matter from dead animals. The potential of processing infected animals remains questionable.

The most promising method of reusing some biomedical wastes is definitely through energy recovery. Such a recovery system might, however, only be feasible by incinerating almost all hospital wastes in order to maintain a constant feed. This energy can be used to provide steam, heat the hospital hot water supply or can be sold to an adjacent facility.

A recent European report was listing placentas as a waste recovery candidate because of the pharmaceutical and cosmetic industry's use of its hormones (Broderson (1982)). However, this practice is less common in America because of the ease of synthetizing hormones (Dr. Ling personal communication).

The European report also refers to a feasibility study done by Batelle Institute on the technical and economic recovery of hospital wastes (Broderson (1982)). The study focused on cellulose, rubber, plastics and metals.' Wastes from all Belgian hospitals would be collected and transported to a central irradiation facility. Wastes would then be sorted in the following manner: oils would be recovered from pyrolysis of plastics, metals from sorting and cellulose fibers from grinding. The major difficulties identified are in relation to the sterilization process: intensity to set the radiation source, reaction of cellulose to the radiation, etc.

The feasibility of sterilization and recycling of toluene has also been demonstrated.

5.4 Disposal

Once the biomedical waste has been segregated, packaged, collected, treated and transported to the final storage area, this waste has yet to be disposed of in an environmentally acceptable manner. There are three disposal methods frequently referenced in the literature and all three are used to some extent in Canada.

5.4.1 Incineration.

5.4.1.1 General. Although some combustion residues still need to be landfilled, the important volume reduction that takes place (up to 95%) (EPA (1986)) during the incineration tends to consider this option as a disposal method.

The following discussion summarizes the documented problems associated with incinerating biomedical wastes:

1. The existing pathological incinerators tend to be outdated (EPS (1985)) because of the increased content of polyethylene, polypropylene and polyvinyl chlorides in the wastes and the increased quantity of biomedical wastes in general (due primarily to the trend of using more disposable hospital supplies and packaging in plastic containers) and more stringent regulations on air emissions.
2. Incinerators require high capital cost investment since they have to be equipped with air polution control devices (for air particulates, halogenated gases, odours) and the water from the scrubbers has to be treated prior to discharge.
3. The sterility of the residue and the air effluent has been questioned (U.C.L.A. (1974), Peterson et al. (1969), Barbeito et al. (1973), Michaelson (1963), Wallace et al. (1972)). One report indicated high concentrations of live organisms in residue of incinerators operating at more than 900°C.

However, despite the above documented problems, incineration of biomedical waste remains the unanimous disposal method for the Canadian Safety Standard Association, the United States Environmental Protection Agency and the World Health Organization from both the environmental and safety point of view.

5.4.1.2 Types of incinerators. This section has been adapted from the recent Ontario Ministry of the Environment Incinerator Design and Operating Criteria (Ontario (1986)).

It presents a summary of the technology available for biomedical waste incineration based on published literature and information obtained from manufacturers and suppliers.

There are basically two types of incinerators that are available for the incineration of biomedical waste in Canada, namely:

- multiple-chamber (retort and in-line);
- controlled-air.

In the past, the most prevalent type of incinerator used for the disposal of biomedical wastes has been the multiple-chamber unit. However, since the mid 1970's, preference has shifted to the controlled-air design.

Regardless of the type of incinerator, it must provide sufficient temperature, turbulence and retention time to ensure complete destruction of the biomedical wastes. The following sections describe the two main types of incinerators in more detail.

1. Multiple-chamber Incinerator

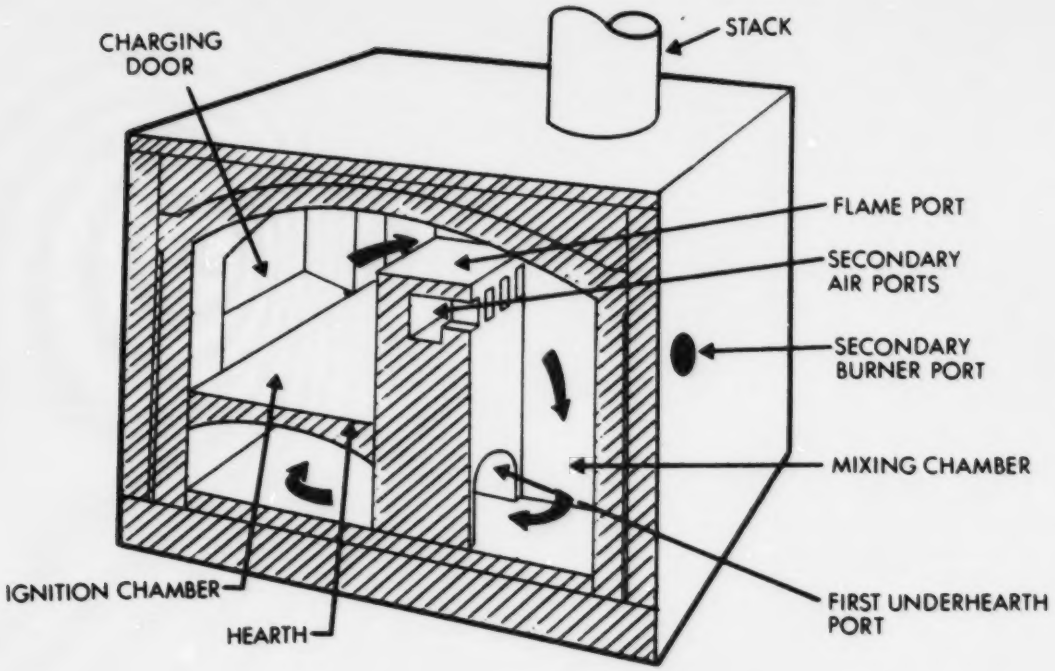
The multiple-chamber incinerator has a minimum of three chambers, passes, or zones. The primary chamber is equipped with a solid hearth (either hot or cold type) complete with a lip (or trough) about 5.0 cm deep to contain fluids. A hot hearth is constructed of conducting refractory and offers significant heat conductivity and a more complete burn. Open grate hearths cannot contain fluids and are therefore not suitable for use in biomedical waste incinerators.

The retort incinerator is characterized by 90-degree directional turns of the gas flow laterally and vertically. The combustion gases may be directed under the solid hearth on which wastes are disposed of, or to the secondary chamber. The flow of hot gases under the solid hearth is advantageous and desirable because it allows for heat transfer to the solid hearth which will aid in combustion in the primary chamber, and helps to ensure sterilization of the resulting ash. A cutaway view of a typical retort incinerator is shown in Figure 5.1.

The in-line incinerator is usually larger and combustion gas flow is directed through 90-degree turns in the vertical plane only. Unlike the retort unit, the in-line incinerator is usually equipped with a grate (Figure 5.2), which renders it unsuitable for wastes with a high fluid content. However, the in-line incinerator can be equipped with a separate hot hearth to accommodate biomedical waste incineration.

Multiple-chamber incinerators have been widely used for the destruction of pathological waste. The basic unit is capable of operating at a high combustion

FIGURE 5.1 Retort Type Multiple-Chamber Pathological Waste Incinerator



Side View:

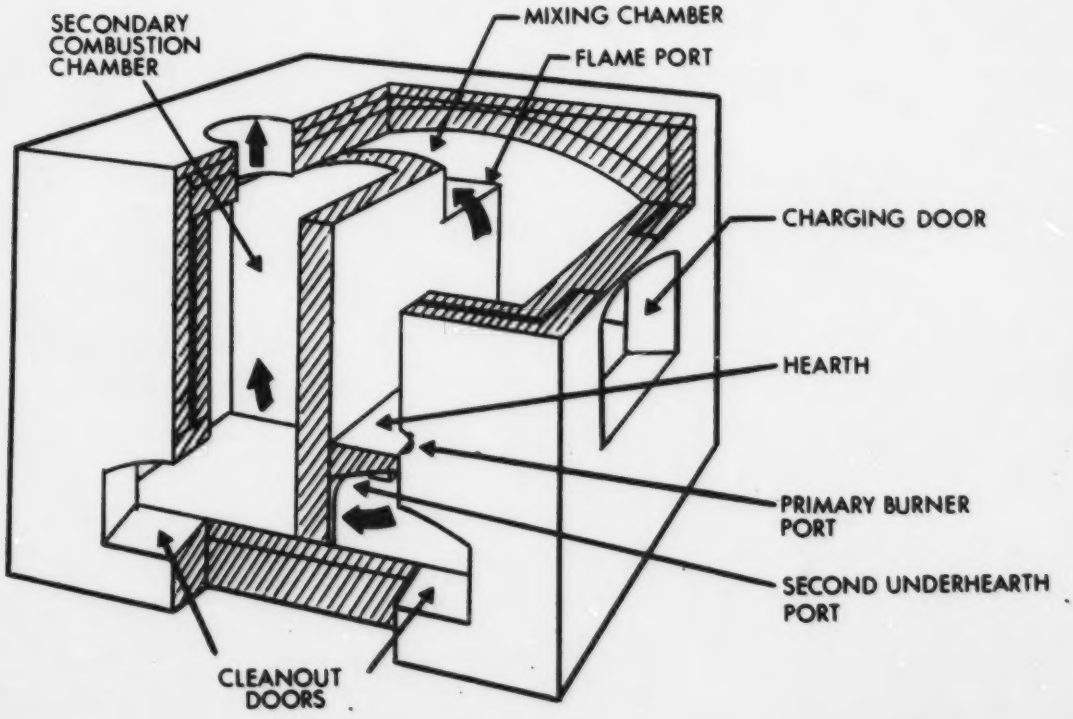
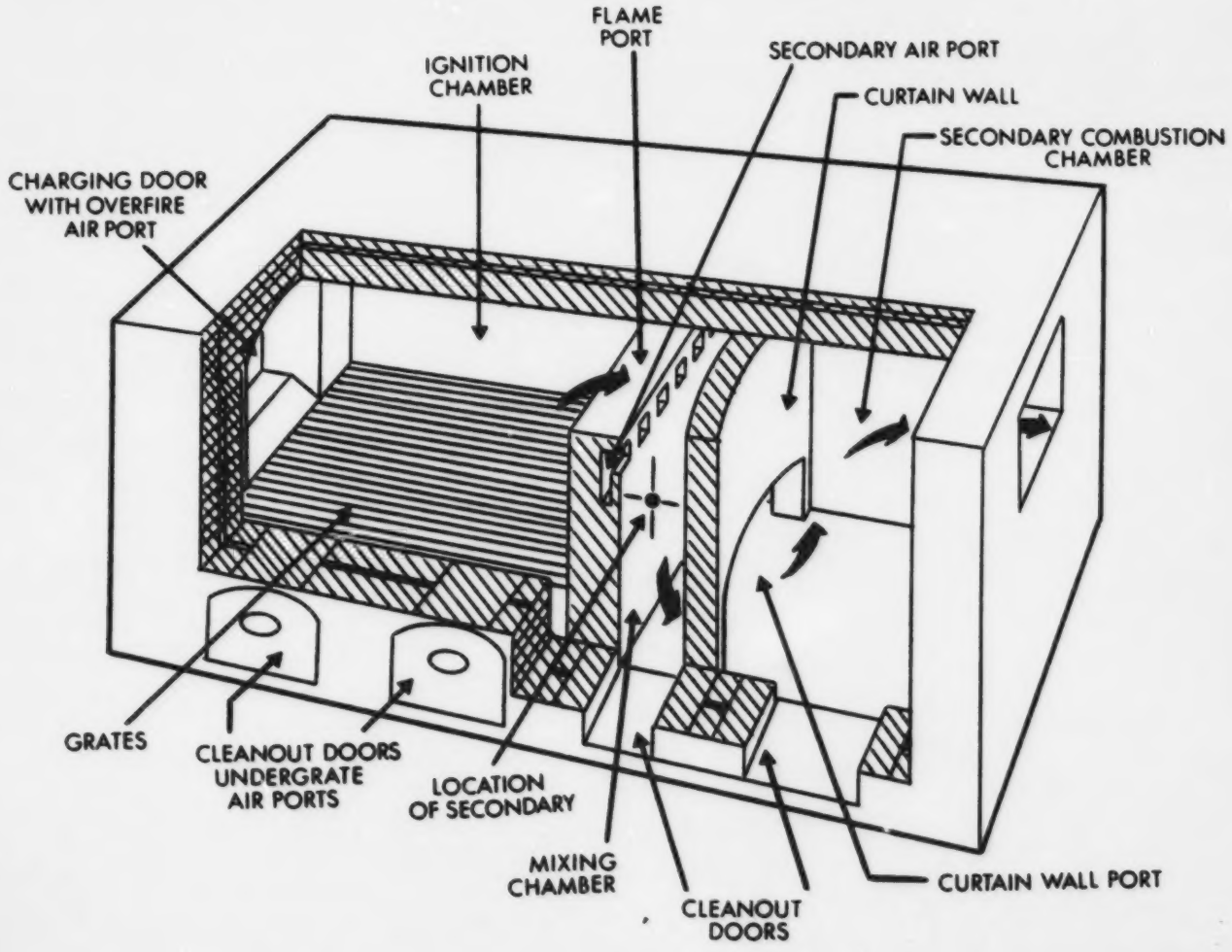


FIGURE 5.2 In-Line Type Multiple-Chamber Incinerator



temperature and appropriate controls can be provided to contain fats and other liquids until burnout is achieved. It can also be operated on an intermittent basis, which makes it particularly amenable to the incineration of anatomical and infectious wastes which are seldom generated in large quantities by a single facility.

Multiple-chamber incinerators operate in the excess air mode with an overall excess air range of 150-400 percent. Combustion air is normally provided by natural draft and admitted through manually-operated ports. Barometric dampers are used to control the draft and thus the quantity of air induced into the incinerator.

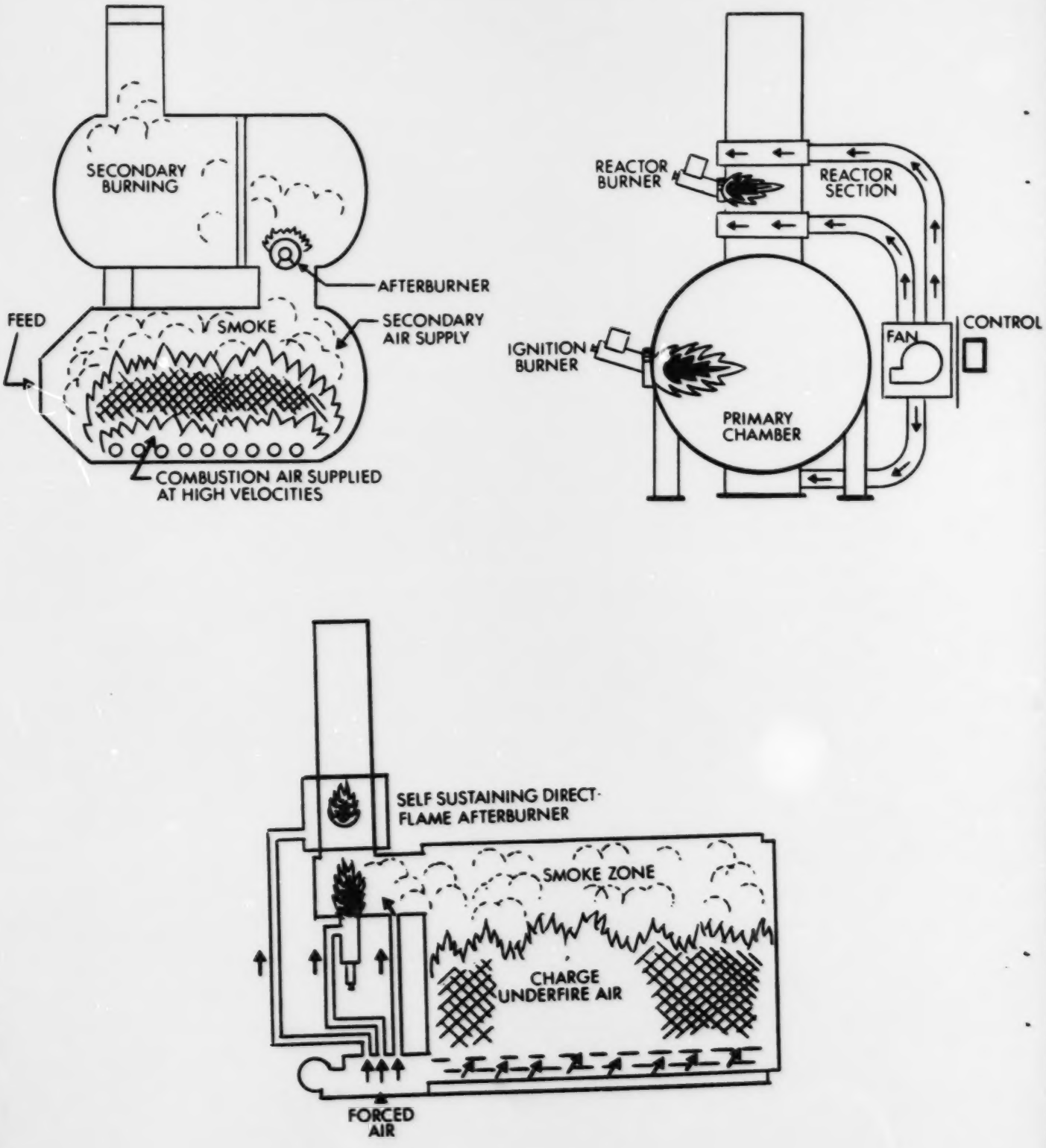
When multiple-chamber incinerators were in widespread use, the composition of pathological waste designated for incineration was not highly variable. The waste had a higher heating value in the order of 2320 kJ/kg (1000 BTU/lb) and required appreciable quantities of auxiliary fuel to sustain combustion during the incineration process. Under these conditions, steady heat input from the burners throughout the total duration of the burn cycle was necessary for complete destruction of the waste.

The physical and thermal characteristics of today's biomedical waste have become much more complex, thereby placing severe limitations on the use of multiple-chamber incinerators. The design is still suitable for burning pathological waste (e.g., animal carcasses) that has a slow heat release rate and a relatively constant oxygen demand. However, most biomedical waste generated today has a much higher heat release rate and greater oxygen demand fluctuation during incineration, due to its higher plastics content. This leads to incomplete combustion causing excessive emissions and opacity problems. In addition, the need for a steady heat input from the burners to maintain the temperature of the larger volume of excess air required for the combustion of plastics has, from an energy cost viewpoint, placed the multiple-chamber incinerator in a non-competitive position compared with other incinerator designs requiring less excess air.

2. Controlled-air Incinerators

The controlled-air incinerator, also referred to as the modular incinerator, makes use of a two-stage combustion process. It usually consists of a primary chamber, followed by a secondary combustion chamber (Figure 5.3). The mode of operation of the primary chamber is used to classify controlled-air incinerators as either excess-air or starved-air (sub-stoichiometric) units. The differences in these two modes of operation are summarized below:

FIGURE 5.3 Typical Configurations of Controlled Air Incinerator



(a) Starved-air incinerator

- provides less than the theoretical stoichiometric quantity of air in the primary chamber (typically 30 to 80% of stoichiometric requirements);
- pyrolysis gases are formed in the primary chamber;
- provides excess air in the secondary or afterburner section to complete combustion (total excess air in the afterburner section varies between 40-250%).

(b) Excess-air incinerator

- provides air in the primary chamber in excess of that required for combustion (typically 60-200% excess air);
- no pyrolysis gases leave the primary chamber;
- promotes almost complete combustion in the primary chamber (in the order of 90-95%);
- gas-phase combustion is completed in the secondary chamber with additional air as required.

Of the two types of controlled-air incinerators, the starved-air unit appears to be more widely used. The success of the starved-air design has, in large part, been due to its ability to reduce the entrainment of particulate matter in the flue gas. This is attributed to the minimum disturbance of the fuel bed and a slower rate of volatilization, which reduces fly ash formation and generates a lower uplift velocity.

Controlled-air incinerators are manufactured by several vendors as standard models that can be modified to suit the specific needs of a customer. Units under 340 kg/h (750 lb/hr) are normally batch fed using a hopper/ram assembly or double ram system to minimize the infiltration of air into the primary chamber during charging. Larger units are usually provided with a continuous waste charging system, such as a screw feeder.

The temperature of the primary chamber is usually maintained in the range of 400-870°C (750-1600°F), whereas the secondary chamber may operate at a temperature as high as 1100°C (2010°F). Retention time for the gas phase in the secondary chamber is in the order of 0.5 to over 1.0 second.

The major difference between the controlled-air and multiple-chamber incinerators relates to the amount of combustion air supplied and the manner in which this is introduced into the unit. In a controlled air incinerator, the rate of combustion air supplied to each chamber is controlled by temperature. Automatic fan damper positioning is normally used to control the air-flow and, therefore, temperature in each chamber.

The controlled-air concept is particularly attractive when incinerating waste materials that exhibit a wide variation in composition, such as non-anatomical biomedical waste. It is better than the multiple-chamber incinerator in that it provides higher combustion efficiency, faster response to temperature fluctuations, and easier operating control.

Conclusion

Of the two types of incinerators, the controlled-air unit is currently the most widely accepted system for the incineration of biomedical waste. The multiple-chamber incinerator, as originally designed, is no longer considered suitable to handle the whole range of biomedical waste currently generated in the hospitals, other health care facilities and medical laboratories. It is, however, still useful for the destruction of waste that has little variation in composition, such as anatomical waste.

5.4.1.3 Operation. In order to optimize the operation of biomedical waste incinerators, US EPA (1982) and Rich and Cherry (1986) identified parameters to be considered when establishing standard operating procedures:

- variations in waste composition (moisture content and heating values differ with type of wastes);
- waste feed rate (optimum feed rate should be set for each type of waste);
- combustion temperature (minimum temperature to attain for a type of waste will be subjected to a trial burn with bacterial spores);
- air feed and fuel feed rates (the sterilizing temperature is maintained by adjusting these parameters);
- internal flow paths (the initial combustion conditions may be altered as units age, are repaired or modified, or waste parameters changed).

5.4.1.4 Emission. It was mentioned earlier that the high capital cost investment when constructing an incinerator is mainly due to the need for air pollution control devices. These devices should control opacity, particulates, hydrogen chloride, dioxins and furans.

Opacity - The Packaged Incinerators National Emission Guidelines (EPS (1978)) of the Environment Canada Clean Air Act recommend that visible emissions should not exceed:

New Installations: Zero (0) Opacity
Existing Installations: 20% Opacity

"Packaged Incinerator" means any furnace used in the process of burning solid waste whose maximum burning rate does not exceed 900 kg of solid waste per hour.

Particulates - The national guidelines also restrict the particulate emissions from any new installations to 0.75 g/kg of solid waste burned.

Hydrogen Chloride (HCl) - For any new installation the same Federal guidelines prescribe a maximum allowable emission of 100 ppm on a dry basis corrected to 50% excess air. If these guidelines were enforced, it would probably shut down every hospital incinerator in Canada with the exception of the new incinerators which comply with the guidelines by scrubbing the gas stream. Although testing data are scarce (Doyle et al. (1985)), levels as high as 800-1400 ppm HCl in the stack gases are common. This is due to the high plastic content of hospital wastes (20%) relative to municipal waste (7%) which creates a more severe problem of acid gases.

In order to achieve a level of 100 ppm HCl, gas scrubbers, usually accompanied by heat recovery boilers to cool the gases prior to scrubbing, are used to reduce the HCl to acceptable levels. Because this control equipment is relatively expensive, the industry will be forced to give serious consideration to larger regional incinerators or larger incinerators located at one hospital but servicing several hospitals in a given area.

Dioxins and Furans - Dioxins and furans are an increasing problem and will probably emerge as the main issue in the siting of new hospital incinerators. Very little testing data exists for the larger incinerators (Doyle et al. (1985)) and in the case of the more numerous smaller incinerators, there is no known data for dioxins and furans. It is possible that most of these older hospital incinerators emit excessive rates of dioxins and furans. This occurs because these incinerators are designed with relatively high burner heat input together with very low levels of air intake for waste combustion due to the high moisture content of the anatomical waste. However, instead of receiving only anatomical waste these incinerators burn mainly paper and plastic waste from which chlorides are released. When combined with the high heat input from the burners and the waste and the low levels of combustion air introduced to the incinerator, poor combustion conditions at high temperatures result, which are an ideal environment for dioxin and furan formation.

The newer controlled air incinerators have probably decreased this problem markedly: tests at the Royal Jubilee Hospital (Doyle et al. (1985)) give total dioxin and furan levels as low as 225 ng/m^3. Although the interim guidelines for PCB destruction facilities (Eaman et al. (1986)) suggest 45 ng/m^3, the installation of a boiler and scrubber will probably reduce the levels from controlled air incinerators even further.

Stack Height Calculations - An important component of incinerator design is the calculation of its stack height. Stack heights are calculated using equations that divide the pollutant emission rate in the stack by the volume of an elliptical cone (Figure 5.4) whose radius "r" is the average height that the gases rise and whose height "hp" is the distance travelled by the plume until the gases first touch the ground (point of impingement) expressed usually in $\mu gms/m^3$. The Federal government has had a policy of containment at source, i.e., stringent emission standards. However, the stack height cannot be determined unless it is accompanied by a point of impingement standard or maximum ground level concentration standard. The " Air Pollution Guidelines Applicable to Incinerators at Federal Establishments" (Canada (1978)) utilize the Federal one hour ambient air quality standards as impingement standards. No standard exists for HCl. Therefore a standard of 100 $\mu gms/m^3$ as recommended by Ontario MOE (Environmental Protection Act, RRO 1980, Reg. 296) should be used to design the stack height. It is assumed that dispersion begins at a theoretical point directly above the stack, whose height (h) is the sum of the actual stack height (hs) and the plume rise (h).

5.4.2 Landfill. Discussions regarding the acceptability of landfilling mixed hospital and infectious wastes are contradictory.

The proponents argue that the disposal of all hospital wastes into the landfill does not present any more threat than disposal of public wastes (UCLA (1974)). No disease contracted respiratory infections had been recorded with refuse workers in the United States until 1977 (Block and Netherton (1977)). Concluding that hospital solid waste containing pathogens can be safely disposed in sanitary landfills, Gordon et al. (1979) gave the following supporting arguments:

- most, if not all pathogens, will not survive the temperatures that are generated in the landfill during aerobic degradation;
- any surviving pathogens would probably be retained by the waste and the soil layers within the landfill;
- pathogens would not likely survive for prolonged periods in landfill leachate;
- pathogens in leachate would not likely be transported through the liner, beyond the borders of the sanitary landfill, to the groundwater.

They recognized, however, the need for additional research in some areas such as characterizing hospital associated pathogens, disease causation, landfill dynamics and their effects on pathogens, landfill selection and operation.

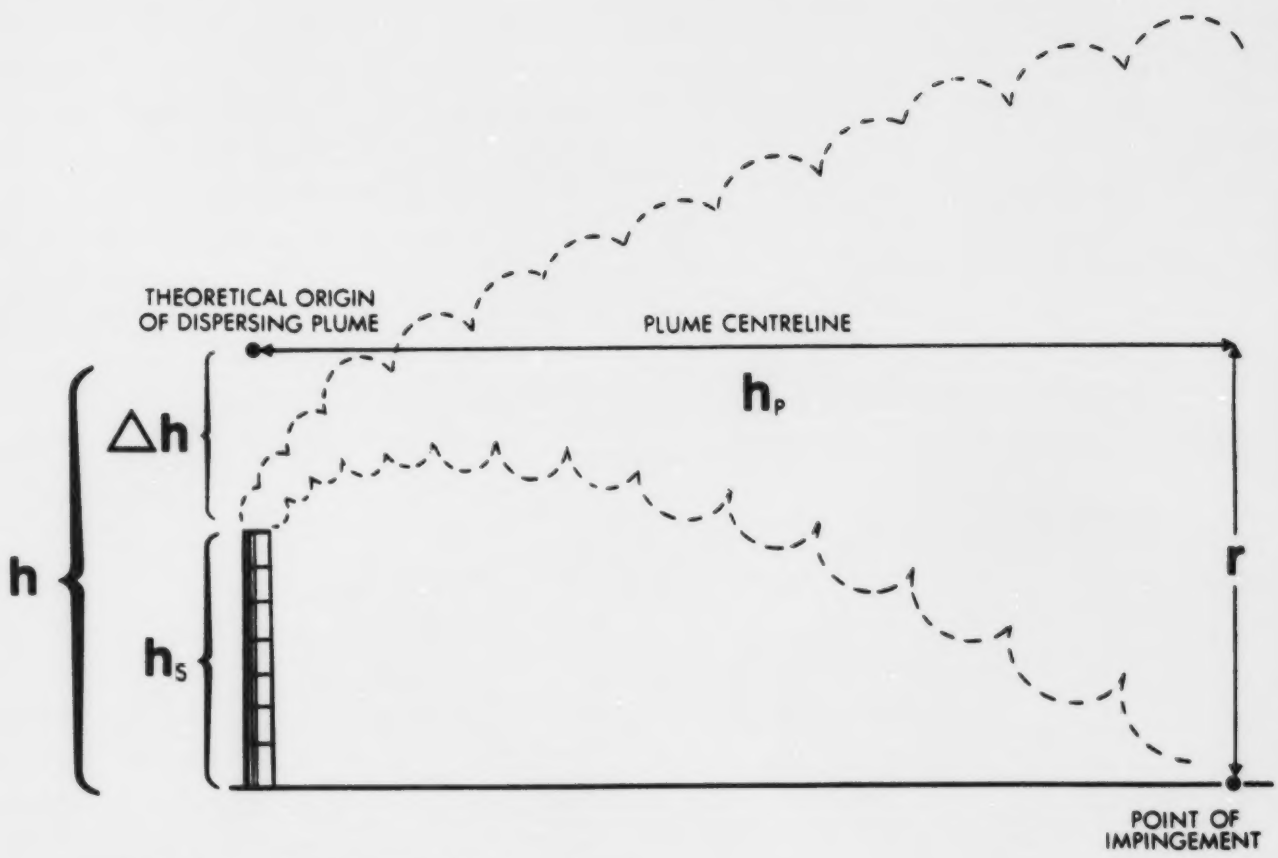


FIGURE 5.4 EFFECTIVE STACK HEIGHT

The opponents contend that "landfilling of medical wastes without sorting or special treatment is unacceptable" (Norris and Young (1978)). The main reason being that these wastes may be subject to scavenging, exposed to potential disease carriers such as rodents and insects, and leached out of the landfill into drinking water sources (Stachiw (1976)). All hospital waste should be considered contaminated and therefore treated, but such a practice would be impractical; failure to sterilize contaminated material as well as aesthetic considerations are among the other reasons (Norris and Young (1978)). In Illinois, a law banning landfilling of infectious wastes was passed in 1981, because this practice posed a public health problem (Brenniman et al. (1984)). Finally, finding sanitary landfill sites that satisfy all the criteria of geological and hydrogeological stability, economic feasibility and public acceptance is becoming almost impossible.

On a more positive note, Block and Netherton (1977) advocate conditioning of the wastes prior to transport from the hospital. "Grinding, shredding, pulping and dewatering or other processes to reduce the mixed, unselected wastes to an unidentifiable homogenous material, followed by sterilization (before, or during the process) will assure a reduced volume and innocuous end-product".

Marriott (1978) defined a properly operated landfill for infectious hospital solid wastes as:

- at least 50 metres away from any place to which the public has access and would be securely fenced;
- operated by skilled personnel;
- the incoming hospital waste would be covered immediately and records of the location would be kept;
- the waste must be properly segregated at the hospital and treated as a hazardous waste during storage, handling and transportation to the disposal site.

WHO says that "general waste and properly treated infectious waste can safely be disposed of in a landfill, but special measures may be necessary for aesthetic reasons".

5.4.3 Sanitary Sewer. The disposal of liquid biomedical waste has been discussed in Section 5.3 and showed that discharging it to the sewage system is suitable if the waste has been properly sterilized. The disposal of hospital solid waste through the sewage system was, until the early seventies, limited to food waste (Iglar and Bond (1973)). These solid wastes are conditioned for the elimination through grinders that macerate them while being mixed with water; the resulting pulp is then discharged to the sanitary sewer system.

Some attempts have been made, in the United States particularly, to extend this practice to all hospital wastes, including biomedical wastes. Grinding solid hospital wastes would be feasible provided that the quantities to be treated are sufficient to justify a grinding facility, a proper segregation of wastes takes place and that the grinders are designed properly (Kremer et al. (1977)). A study done in Los Angeles on the use of grinders found that the most serious problem encountered was the difficulty to grind soft material such as rubber items (Weintraubard and Kern (1969)). It concluded that the ideal facility would have sufficient available water sources, adequately sized sewer connnections, sufficient electrical power and a large grinding unit. Some difficulties that were also identified were the noises created, as well as the potential for hazardous

aerosols; the fact that the pathogens are not affected by the process is also a serious limitation.

In 1984, wet grinding of infectious wastes had not yet been tested on a large scale, and was qualified as "needing more research" (Brenniman et al. (1984)).

6 GUIDELINES AND RELATED DOCUMENTS

The recent awareness of the hazard of biomedical wastes has translated into the development of several guidelines and related documents in Canada. Over the last fifteen years, many provincial and national associations, groups or departments have prepared guidelines giving step-by-step instructions on the proper management of biomedical material, equipment and resulting wastes. The following summarizes some of those documents made available by their authors or through library services:

6.1 Provincial and Territorial

6.1.1 British Columbia. The British Columbia Ministry of Environment does not have specific guidelines pertaining to the management of biomedical wastes. Enquiries on the topic are referred to the CSA Standard Z317.10-M1981 " Handling of Waste Materials Within Health Care Facilities". Requests for information on the management of antineoplastic drugs are filled by sending copies of articles and guidelines from the technical literature and other jurisdictions.

The same situation prevails with the Ministry of Health except they have no means of statutory or regulatory control of biomedical wastes.

6.1.2 Saskatchewan.

Incinerator Guidelines

Air Pollution Control Branch
Saskatchewan. February 1984

These guidelines recommend that only the most efficient incinerator designs may be used for hospital wastes or other wastes that may pose either an air pollution or a health problem if imporperly processed. Specific requirements will be prepared and provided on a case by case basis, upon request.

Emission Guidelines

In Saskatchewan, no person shall install or operate an incinerator which emits:

(a) an opacity in excess of 20% averaged over a six consecutive minute period;
(b) particulate matter in excess of 0.25 grams per dry standard cubic metre of flue gas, corrected to 12% carbon dioxide by volume;
(c) hydrogen chloride (HCl) in excess of 100 parts per million by volume on a dry basis, corrected to 50% excess air;

(d) sulphur dioxide in excess of 250 parts per million by volume on a dry basis, corrected to 50% excess air.

6.1.3 Manitoba. Guidelines for Preparation, Administration and Disposal of Chemotherapeutic Agents, Manitoba Cancer Treatment and Research Foundation, St. Boniface General Hospital, 409 Tache Avenue, Winnipeg, Canada, 1984.

These guidelines have been established in order to provide a minimum acceptable level of protection for health care personnel managing antineoplastic drugs in the Province of Manitoba. These procedures have been approved by the Provincial Department of Environment and Workplace Safety and Health.

The different topics are:

i) General guidelines
ii) Apparel, equipment and facilities
iii) Drug preparation
iv) Drug administration
v) Housekeeping, disposal, management of spills and contamination
vi) Screening of staff

Section V deals more specifically with the management of the wastes generated by spills, left overs and unused drugs.

First aid actions and cleanup procedures in spill situations are given.

The discussion on waste disposal is limited to the handling precautions to be taken in order that they can be safely returned to the hospital pharmacy. Disposal measures for pharmacy personnel are not given.

6.1.4 Ontario.

(i) Incinerator Design and Operating Criteria, Volume II, Biomedical Waste Incinerators, Ontario Ministry of the Environment, 1986

The first portion of the document gives general information on biomedical wastes: classification, origin, handling, generator rates and characterization.

Three technologies for biomedical waste incineration are presented, namely: Multiple-Chamber Incinerator, Controlled-Air Incinerator and Rotary Kiln Incinerator. The Controlled Air unit is the most widely accepted system for the incineration of biomedical waste.

The last section discusses eleven (11) different design and operating criteria:

- Feed System
- Primary Chamber
- Secondary Chamber
- Turbulence
- Air Requirements
- Burners
- Process Monitoring/Control
- Quenching
- Ash Disposal
- Operating Procedure
- Incinerator Stack

(ii) A Guide for the Safe Preparation and Disposal of Antineoplastic Agents, Hospital Occupational Health and Safety Services, Ontario Hospital Association, 1982

The objectives of this guide are to increase awareness of the potential hazards of antineoplastic agents and to assist hospitals in establishing procedures which will minimize these hazards. It describes recommended procedures for preparation, transportation and disposal of the drugs and contaminated materials, as well as guidelines about personal protective equipment and the selection of an appropriate work area.

Some of the recommendations with regard to waste management are:

- After use, syringe needles should not be clipped in order to avoid scrattering droplets of the drug. The syringes should be capped and discarded;
- Sharps and breakable contaminated items should be discarded into "sharps" standard container (in accordance with CSA Standard Z317.10-M1981);
- Disposable items should be discarded into yellow plastic bags (bag specifications are in the guide);
- Disposables, sharps and breakable contaminated items should be discarded in accordance with CSA Standards;
- Securely closed waste bags should be transported in an open or closed cart at least daily to a predetermined area; that area should be totally enclosed and separate from supply rooms or food preparation areas;
- Three methods for disposing of antineoplastics are discussed: chemical degradation, disposal in landfill sites and incineration.

(iii) Guidelines for the Handling and Disposal of Biomedical Wastes from the Health Care Facilities and Laboratories, Ministry of the Environment, 1986

These guidelines cover the special precautions associated with the handling, storage, collection, transportation and disposal of biomedical wastes from health care facilities and laboratories. They are to be followed unless other measures taken are directed, or expressly permitted by other applicable Ontario or Federal legislation.

The content of this document is as follows:

1. Definition and classification of waste
   - Biomedical (pathological and infectious)
   - Others (non infectious, non anatomical, sharps, etc.)
2. Packaging of biomedical wastes
   - Human anatomical waste
   - Animal anatomical waste (infectious)
   - Non anatomical waste (infectious)
   - Sharps
   - Waste -- Non Infectious
3. Disposal of biomedical wastes
   - Incineration (for pathological and infectious wastes)
   - Steam decontamination (for infectious, non anatomical)
   - New technology (subject to the approval of the appropriate provincial authority)

3.1 Disposal of other types of biomedical waste
   - Decontaminated waste requiring special handling
   - Sharps

3.2 Liquid infectious waste disposal

3.3 Blood or blood products

3.4 Waste -- non infectious -- requiring special handling

4. Rigid containers for untreated pathological and biomedical wastes

5. Storage of biomedical wastes

Factors to consider when storage is unavoidable:

- access limited to authorized personnel;

- integrity of the packaging maintained;
- duration of storage;
- temperature

6. Protection of personnel according to the Occupational Safety Act administered by the Ministry of Labour, and the Health Protection and Promotion Act of the Ministry of Health
7. On-site disposal
8. Off-site disposal

Any person engaged in the transportation of waste to a disposal site has to comply with the Environmental Protection Act, RSO 1980, and Ontario Regulation 309, as amended, and other Provincial and Federal Acts and Regulations.

9. Sharing of existing incinerator facilities is permitted under recent amendments to Regulation 309 under the Environmental Protection Act.
10. Inter-hospital transportation of biomedical waste.

(iv) Guidelines for the Handling of Potentially Infectious Biomedical Waste from Medical Laboratories and Specimen Collection Centres. Ontario Association of Medical Laboratories. 1985.

(Document not obtained.)

(v) Guidelines for Vehicles Transporting Anatomical Infectious Waste. Ministry of the Environment. 1985.

(Document not obtained.)

(vi) Guidelines on the Safe Operation of Steam Autoclaves. Laboratory Safety Manual. Laboratory Services Branch. Ministry of Health. 1982.

(Document not obtained.)

(vii) A Strategy for the Management of Biomedical Waste. Report of the Interministry Task Force on Biomedical Waste. 1986.

Subsequent to a public health emergency in Ontario in 1984, the authorities and the health care industry recognized a shortage of licensed and approved haulers for biomedical wastes. In an effort to identify the difficulties faced by hospitals regarding disposal of waste, a Biomedical Waste Task Force was established by the Ministries of Environment, Health and Labour. The mandate of this Task Force was to resolve the

immediate threat to public health and to develop a long term management strategy for the disposal of biomedical waste.

The conclusion of the Task Force was summarized into 12 recommendations. Major recommendations are as follows:

- The government should promote the establishment of regionally centralized biomedical waste disposal facilities.
- Short-term low cost actions by hospitals to upgrade deficient incinerators should be rapidly implemented wherever feasible.
- Detailed combustion engineering analyses should be carried out on those hospital incinerators identified to be deficient.
- The Ministry of Health should set aside a special budget to assist hospitals in the upgrading of existing incinerators.

(viii) Occupational Health and Safety Guidelines on the Operation, Maintenance and Repair of Biomedical Waste Incinerators. Ministry of Labour. 1984.

(Document not obtained.)

6.1.5 Quebec. Quebec is currently drafting a policy specific to Biomedical wastes. This policy along with an action plan was planned for 1986.

6.2 National

6.2.1 Agriculture Canada. Safety Guide for Laboratory Operations. Animal Diseases Research Institute. Agriculture Canada. 1982.

This Safety Guide was originally developed by and for the A.D.R.I. in 1979 but its use is now widespread throughout the Animal Pathology Division of the Food Production & Inspection Branch, Agriculture Canada.

Section 5 of the present guide addresses not only the biological hazards and safety procedures but also the disinfection and sterilizatic procedures, the monitoring and safety procedures and the disposal of laboratory wastes.

Disinfection and Sterilization

"All infectious or toxic materials, equipment or apparatus should be autoclaved or otherwise sterilized or detoxified before being washed or discarded".

Wet heat (steam sterilizer), dry heat and ethylene oxide are three sterilization methods recommended.

Monitoring Safety Procedures

All safety equipment must be monitored routinely in order to maintain it at maximum efficiency. This applies to ultraviolet lights, air pressure differentials, biohazard safety cabinets and sterilizers.

Disposal of Laboratory Wastes

Recommendations are made for infected tissue, glassware, plastic, paper and liquids, as well as non-infected material, tissue, glassware, plastics and paper.

Tissue (infected or non-infected) - incineration
Glassware (infected) - sterilization, then disposal or reuse
Plastic (infected) - incineration
Liquid (infected) - incineration

The suggested levels of containment for laboratory procedures are based on the "Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells", Medical Research Council, 1977.

6.2.2 Canadian Standards Association. Handling of Waste Materials Within Health Care Facilities, Standard Z317.10-M, 1981, Rexdale, Ontario

The scope of this standard is to develop criteria for the segregation, collection, movement and storage of waste material within health care facilities. The main objective is to decrease the possible risks of the spread of infection and injury to personnel due to the improper handling of waste material.

As a supplement to the standard, some recommendations are made dealing with the transportation, disposal and incineration of pathological (CSA does not use the term biomedical) waste from the health care facility.

The great merit of this document is that it sets a standardized classification for wastes from hospitals, clinics, doctors' offices and laboratories. Each type of waste within a class has a corresponding color coded container (either plastic bag or rigid plastic container) to allow for appropriate segregation of the waste at the point of generation and thus, insuring an adequate management. For pathological waste more specifically, the colour coding is:

Type of Waste	Colour Coding	Additional Marking
Human Anatomical	Red	Biohazard and Symbol if infectious, otherwise none
Infected Animal Anatomical Waste	Blue or Orange	Biohazard Symbol
Infected Non-Anatomical	Yellow	Biohazard Symbol

See symbol on TDGR Label (Figure 7.1)
Subject to regulations set by the Provincial Regulatory authority

The classification scheme is as follows:

General Wastes	Pathological	Radioactive	Chemical
Kitchen Wastes	Human Anatomical	Laboratory	General
Shop Wastes	Wastes	Patient Asso-	Hazardous
Institutional Wastes	(Class 1)	ciated Wastes	- Acids
- Non-infected Animal	Infected Animal		- Azides
Anatomical Wastes	Anatomical Wastes		- Toxic Salts
(Type A)	(Class 2)		- Metallic
- Non-Infected, Non-	Infected Non-		Mercury
Anatomical Wastes	Anatomical Wastes		Organic
(Type B)	(Class 3)		Solvents
Glass	- Liquids		- Halogenated
Miscellaneous	- Sharp Instruments		- Non-Halo-
	- Infectious Material		genated
	- Contaminated Drugs		

The disposal methods recommended in the supplement are as follows:

1. Incineration for all pathological waste in an incinerator approved for this purpose.
2. Except for human anatomical wastes, disposal into a properly operated sanitary landfill site approved for this purpose. Sterilization of waste at the source is recommended.

6.2.3 **Canadian Society of Hospital Pharmacists.** 1983.

Guidelines for the Disposal of Hazardous Pharmaceuticals

These guidelines have been prepared by the Canadian Society of Hospital Pharmacists (CSHP) in recognition of the fact that pharmacists cannot indiscriminately dispose of pharmaceutical wastes without considering the impact on the environment, public health and hospital staff safety.

Only basic methods of disposal are outlined:

Disposal of pharmaceuticals (particularly narcotics and controlled drugs, cytotoxics and biologicals), radiopharmaceuticals and chemicals are discussed.

With regard to cytotoxic chemicals, the following are some of the recommendations made:

- Policies and procedures shall be developed to govern their management;
- Waste should be segregated in accordance with the disposal methods;
- Waste generation should be minimized through preplanning;
- Recycling of intact pharmaceuticals (unopened vials, ampoules or bottles) to the distributing agent should be arranged whenever such an arrangement is possible;
- When double-bagging is used to contain waste, the inner bag shall be at least 0.051 mm in thickness; the outer bag should be yellow with a biohazard symbol;
- Patient-associated wastes contaminated with cytotoxics shall be stored in a container displaying a biohazard symbol;
- When outdated waste pharmaceuticals cannot be returned to the supplier, incineration design to a 0.5 second retention time at 1000°C downstream of the second burner should be considered; in some cases, incineration is not suitable (toxic gas emissions); for some cytotoxics, chemical deactivation or degradation may be used;
- Contaminated sharps (blades, needles, glassware, etc.) should be contained in puncture resistant containers such as rigid plastic.

6.2.4 (i) Environment Canada

Air Pollution Guidelines Applicable to Incinerators at Federal Establishments. Environmental Protection Service. Environment Canada. 1978.

These guidelines set forth emission limits for air pollutants discharged from new and existing incinerators at federal establishments.

Visible Emissions

New Installation: Opacity less than or equal to 5%
Existing Installation: Opacity less than or equal to 20%

Particulate Emissions

New Installation: (i) 0.75 g/kg of solid waste burned for solid waste types A to L at a rate of less than 900 kg per hour.

(ii) 1.00 g/kg of solid waste burned for solid waste types A to L at a rate equal to or greater than 900 kg per hour.

Existing Installation: should not create a nuisance or air pollution (as defined in this guideline).

Gaseous Emissions

Hydrogen Chloride: should not exceed 0.85 g/kg of solid waste burned.

Sulphur Dioxide: should not exceed 3.6 g/kg of solid waste burned.

These guidelines also specify a method of stack height calculations using the Federal Ambient Air Standards as impingement standards. Although HCl is not included in these standards, the Ontario standard of 100 mgms/m^3 should be considered for this purpose.

Wastes, types E, J, K and L contain biomedical wastes and are subjected to the federal guidelines:

Type E -- Plastic and asphaltic solids, halogenated (i.e., PVC) and DDT powder.
Type J -- Pathological materials (i.e., hospital dressings, disposable bedding and gowns).
Type K -- Pathological remains (i.e., dead animals, parts of humans and animals).
Type L -- Cadavers, coffin encased.

(ii) Environment Canada

Packaged Incinerators National Emission Guidelines. 1978. Clean Air Act.

These guidelines indicate quantities in which particulate matter, hydrogen chloride and sulphur dioxide should not be emitted into the ambient air from new installations of packaged incinerators (furnace used in the process of burning solid waste

whose maximum burning rate does not exceed 900 kg of solid waste per hour). Visible emission limits are recommended as a practical means of assessing the performance of both new and existing sources.

Emission Limits for New Installations

Gases discharged to the atmosphere, as a consequence of the operation of a new installation, should not:

(a) exhibit visible emissions which exceed zero opacity;
(b) contain particulate matter in excess of 0.75 g/kg of solid waste burned;
(c) contain hydrogen chloride in excess of 100 ppm on a dry basis and corrected to 50% excess air;
(d) contain sulphur dioxide in excess of 250 ppm on a dry basis and corrected to 50% excess air.

Emission Limits for Existing Installations

Gases discharged to the atmosphere as a consequence of the operation of an existing installation should not exhibit visible emissions which exceed 20% opacity.

6.2.5 (i) **Medical Research Council of Canada.** 1980.

Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells, Ottawa

These guidelines are to be implemented in every Medical Research Council funded facility whose research involves recombinant DNA molecules and animal viruses and cells.

As part of the major potential factors contributing to the dissemination of hazardous agents outside the biohazard facility, air, liquid and solid effluents are identified. Safety devices and procedures are recommended in order to minimize these risks. The following precautions are recommended:

Air

- An exhaust system allowing for 10 room volume per hour exchange and filtering through a decontamination system, if required.
- HEPA (High Efficiency Particulate Air) filter is recommended. Such a filter has to be decontaminated upon replacement. Once decontaminated and dried, the HEPA filter has to be autoclaved or incinerated.

Liquids

Liquids in which agents have been cultured must be inactivated before entering the sewage system. Proper inactivation can be achieved by autoclaving or disinfection with sodium hypochlorite and detergent.

Solids

- Reusable items must be autoclaved whenever possible without damaging the items; chemical disinfectant might be an alternative.
- Disposable items should be incinerated or autoclaved prior to disposal.

Six containment levels (A to F) are defined. There is one containment level for every type of experiment involving recombinant DNA molecules, animal viruses or cells.

6.2.5 (ii) Medical Research Council of Canada. 1980

Design, Operation and Maintenance Supplement to the Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells

This supplement elaborates on the design, operation and maintenance of a Biohazard Laboratory.

Specific recommendations are made for the management of wastes according to the level of containment required.

6.2.6 Campbell, B.A., M.D. Pequegnat, A.J. Clayton. 1984. "A Hospital Contingency Plan for Exotic Communicable Diseases", In Infection Control. Vol. 5, No. 12, p. 565-569. The authors are from the Bureau of Infection Control, Laboratory Center for Disease Control, Health Protection Branch, Health and Welfare Canada, and the Ottawa Civic Hospital, Ottawa.

The document cited above is a first attempt to develop a practical contingency plan to deal with patients having been admitted to a hospital or presumptively diagnosed as having an exotic communicable disease (ECD) once admitted to the hospital.

There are six ECD's listed by H&WC; Lassa fever, Marburg virus disease, Ebola cirus disease, the two South American hemorrhagic fevers --Junin and Machupo, and the Pneumonic Plague.

The authors recommend a series of specifications to be included in the Hospital Contingency Plan. These measures are aimed at protecting the personnel, and patients, as well as the visitors and the general public in the community. Special

attention is given to the selection of the isolation rooms to the treatment and disposal of any waste resulting from the care of the infected patient.

Specifications related to the wastes from ECD's are as follows:

1. Arrangements must be made for the removal of contaminated wastes in such a way as to limit exposure to these items as much as possible. These items should be double-bagged, transported to the autoclave in rigid, unbreakable containers under supervision and then to the incinerator.
2. All protective clothing (gowns, masks, caps, boots and gloves) must be double-bagged in autoclavable bags, autoclaved (assuring a proper time and pressure according to the load) and then incinerated.
3. Sphygmomanometers and stethoscopes should be double-bagged in plastic bags and sterilized with ethylene oxide before reuse. If an ethylene oxygen sterilizer is not available, reusable equipment should be autoclaved and then incinerated.
4. Needles and syringes should be placed in puncture-resistant containers, double-bagged in autoclavable bags, autoclaved and then incinerated. Needles should not be recapped or bent after use.
5. All liquid wastes, including bed bath wastes, must be treated by diluting with 5.25% commercial sodium hypochlorite to a 1:5 solution. Let stand 24 hours and pour into wide mouth polypropylene containers. These should then be autoclaved and poured into the sewer system.
6. All solid wastes, excreta and disposable items such as clothing, linen, bed pans and dishes must be double-bagged in autoclavable bags, autoclaved, then incinerated.
7. Patients clothing and personal effects should be double-bagged in plastic bags and sterilized with ethylene oxide. If this type of sterilizer is not available, these items should be autoclaved in autoclavable bags and then incinerated.
8. All items used in the cleaning and disinfection of the isolation room during and after the isolation period should be double-bagged and incinerated.
9. After autopsy, the body should be triple-bagged in large commercial type plastic bags. After removing the maximum amount of air, the body should be sprayed with 10% formalin. The body should be placed in a coffin, which is then filled with sawdust impregnated with 10% formalin and cremated or buried in accordance with provincial regulations.

6.2.7 Treasury Board of Canada. 1982. Safety Guide for Laboratory Operations. TB Guide 5-1, 2nd Edition. There are a number of activity areas within the Public Service

of Canada that require specialized guidelines and information. This guide has been designed to assist departments and agencies in the establishment of programs for the prevention of laboratory work-related accidents, injuries and illness.

With regard to biomedical waste management, the TB Guide is proposing the following related codes, standards and references:

Utilities

A central vacuum system should not be connected to zones which are potential sources of contamination and from which the system could spread the hazard (such as microbiology areas); vacuum requirements in these areas should be created by a separate vacuum pump in each room requiring the service.

Biological Considerations for Design

- Laboratory buildings for handling micro-organisms pathogenic to humans should be zoned into areas designated as (a) clean and (b) contaminated, separated by an air lock with an ultra-violet (U.V.) door barrier and ceiling mounted U.V. lights.
- Separate, clean and contaminated change rooms, with an air lock between them should be provided to serve as transitional areas through which personnel enter and leave the potentially infectious parts of the building. Shower facilities, or space for their future installation, and lockers for sheet clothing should be provided. The contaminated change room should contain a U.V. sterilized discard clothing rack and a ventilated storage space for laboratory shoes. Effluents from contaminated areas may require treatment and should be directed to special holding tanks.

6.3 Others

6.3.1 **Environmental Protection Agency.** EPA Guide for Infectious Waste Management, Office of Solid Wastes Wastes and Emergency Response, Washington, DC. 20460 PB86-199130

This manual is a very complete document in the way that it characterizes the wastes (13 types identified), identifies the principal generators and gives recommendations on the management of those wastes (segregation, packaging, storage, transportation on/off site and treatment and disposal techniques).

6.3.2 **World Health Organization: Management of Wastes from Hospitals and Other Health Care Establishments, Conference, June 28th to July 1st, 1983.** In 1983, the World Health Organization Regional Office convened a meeting in Bergen, Switzerland with a

Working Group on Hospital Waste Management. This meeting was to review recent developments in waste management in health care establishments and to prepare guidelines for a code of good practice to be used by administrators, engineers and others in industralized countries.

The workshop's conclusions and recommendations regarding Biomedical Wastes are the following:

- Health care waste management required a systems approach, involving the handling, storage, transport, treatment and disposal of waste by methods that at all stages minimize the risk to health and the environment.
- All personnel in health care establishments should be made aware of the potential risks of mishandling waste. Training for all personnel involved in waste management is an essential part of health care training programmes.
- Emphasis should be placed on the need to segregate "risk" waste -- pathological, infectious, hazardous chemical - from other waste and to use appropriate packaging and labels. Colour-coding of waste bags and containers should be adopted with appropriate emblem-coded tags for high-risk waste. National standardization of colour and emblem coding would be advantageous.
- The basic approach to waste management is to reduce the quantity of waste at source as far as practical. In health care waste management, this is particularly significant for chemicals. Waste should be recycled whenever feasible, with due regard to environmental considerations, to reduce the quantity of material entering the waste stream.
- Incineration is the preferred method of disposing of pathological and infectious waste. Incinerators must be specifically designed to deal with such waste and be able to meet local or national emission standards.
- All health care establishments should have comprehensive waste disposal plans. Policies for disposal will vary with local circumstances. It may be carried out on-site or at a centralized plant. In planning new hospitals or other health care establishments, or their renovation, full account must be taken of the need for waste disposal, including provision for future extensions.
- Legislation on health care waste management should be restricted to basic principles, leaving individual health care establishments or units to adopt the systems that suit them best. The feasibility of local health care establishments

cooperating with each other should be considered, with a view to minimizing waste disposal cost.

- Information needs to be collected and exchanged on the performance and capabilities of various health care waste treatment and disposal techniques, especially incineration. Demonstration projects reflecting different national waste management strategies would be beneficial.

7 LEGISLATION

In Canada, there is no specific legislation dealing with the management of biomedical wastes. Only selected aspects are included in laws designated for environment, public health or transportation. In most cases, disposal at landfills and into the sewer systems remains a municipal jurisdiction.

7.1 Provincial

Only two provinces are known to have specific mention of biomedical waste in their legislation: Ontario and British Columbia. In Quebec, the relevance of including these wastes in the Hazardous Waste Regulation is under revision.

7.1.1 British Columbia. Waste Management Act, Special Waste Regulation (not in effect), British Columbia Ministry of the Environment

Under this regulation, infectious wastes are listed as a Special Waste and defined as an "infectious material that results from biological research or is produced by or comes from a medical laboratory or a hospital".

The amount of infectious waste permitted to be stored under Section 4 of the Waste Management Act without a permit is 10 kg.

The amount of infectious waste permitted to be transported under Section 5 of the Waste Management Act without a manifest is 1 kg.

7.1.2 Alberta.

Clean Air (Maximum Levels) Regulations
Clean Air Act
Alberta Regulation 218/75 (as amended)
Alberta Environment

Articles of relevance to biomedical waste management in these regulations:

1.(h) "Maximum permissible concentration" means the maximum permissible concentration of an air contaminant at the point of measurement.

Part 1 - Maximum Permissible Concentration of Air Contaminants in the Ambient Air

7. Suspended particulates in the ambient air shall not exceed an average maximum permissible concentration of

(a) 60 micrograms per cubic meter as an annual geometric mean;

(b) 100 micrograms per cubic meter as a 24 hour concentration.

Part 3 - Particulate Emissions -- General

12.(2) The concentration of particulates in an effluent stream to the atmosphere shall not exceed

(b) 0.20 pounds per 1000 pound of effluent resulting from (xviii) refuse incinerators having a capacity of greater than 500 pounds per hour.

(d) 0.60 pounds per 1000 pounds of effluent resulting from (iv) refuse incinerators having a capacity of less than 500 pounds per hour.

7.1.3 Manitoba.

Incinerator Regulations
Clean Environment Act
Manitoba regulation 334/74
Department of Environment, Work Place Safety and Health

3.(1) No person shall operate any new incinerator which emits more than 0.23 grams of particulates per standard cubic meter (0.10 grams per standard cubic foot) of dry flue gas corrected to 12 percent carbon dioxide by volume.

(2) No person shall operate a new incinerator which emits smoke the opacity of which is equal to or greater than

(a) 40 percent at any time; or

(b) 20 percent for a period exceeding 4 minutes in any one hour

7.1.4 Ontario.

(1) Environmental Protection Act (General Waste Management), Regulation 309, June 1985, Ontario Ministry of the Environment.

Under this regulation, a pathological waste is a "hazardous waste" and is defined as:

i) any part of the human body, including tissue and bodily fluids, but excluding fluids, extracted teeth, hair, nail clippings and the like that are non-infectious,

ii) any part of the carcass of an animal infected with a communicable disease or suspected by a licenced veterinary practitioner to be infected with a communicable disease; or

iii) non-anatomical waste infected with a communicable disease.

Waste from clinics that provide medical diagnosis or treatment; research or experimental enterprise or activity; or schools, laboratories or hospitals, are defined as "industrial waste".

Under "subject waste", hazardous waste does not include waste from:

i) a nursing home under the Nursing Homes Act;
ii) a home under the Homes for the Aged and Rest Homes Act;
iii) a home for special care under the Homes for the Special Care Act;
iv) the professional office of a member of the Royal College of Dental Surgeons of Ontario; or
v) the professional office of a member of the College of Physicians and Surgeons of Ontario.

Under this regulation, it is required that pathological wastes be transported, handled and disposed by specialized haulers and facilities. Hospitals are responsible for segregating pathological wastes from the general wastes.

(2) Environmental Protection Act (Ambient Air Quality) Criteria Regulation
Regulation 296, 1980
Ontario Ministry of the Environment

According to this Regulation incinerator emissions should not exceed:

(i) 100 micrograms of hydrogen chloride per cubic metre of air at the point of impingement (half hour average).
(ii) 100 micrograms of total suspended particulate matter per cubic metre of air (particulate less than 44 microns in size).

7.1.5 Quebec.

(1) Environment Quality Act (Hazardous Waste Regulation)
Regulation 1000-85
Department of the Environment

Under Article 6.(10) pathological waste is excluded from this regulation.

6. Exclusion: The following waste is not a hazardous waste:

(10) pathological

(2) Environment Quality Act (Regulation Respecting the Quality of the Atmosphere)

R.R.Q. 1981, c. Q-2, r. 20

Department of the Environment

Division IV -- Opacity of Emissions

10. Opacity Standards

The concentration of contaminants discharged into the atmosphere by a stationary source must not exceed 20% of opacity.

Division XIX -- Incinerators

67. Emissions

An incinerator other than a hazardous waste incinerator must not emit into the atmosphere:

(a) particulate matter in excess of what is prescribed in the following table:

Class of Incinerator	Capacity of the Incinerator	Standard
Existing Incinerators	LE 1 tonne/h GT 1 tonne/h	150 g/100 kg refuse 270 mg/Nm^3 gas
New Incinerators for pathological refuse	any capacity	100 g/100 kg refuse
Crematory	any capacity	100 g/100 kg of charged material

LE: less or equal
GT: greater than

(b) more than 10% of unburned particulate matter in excess of 5 micrometres, over the standard prescribed in the table of subparagraph (a) of this section, as collected in the sampling device;

(c) particulate matter individually visible at the point of emission;

(d) gases containing hydrochloric acid having a concentration higher than 500 parts per million (volume).

7.1.6 **New Brunswick.**

Clean Environment Act (Air Quality Regulation)
N.B. Reg. 83-203
New Brunswick Department of Municipal Affairs and Environment

Part II -- Smoke Density Standards

11. No person, without the written consent of the Minister, shall cause or permit emission of smoke which has a density greater than 20%, except that for an aggregate period of not more than four minutes during one half hour, smoke may have a density greater than 20% but not exceeding 40%.

20. No person shall emit or permit the emission of any air contaminant such that the maximum permissible ground level concentrations as set out in Schedule B are exceeded.

SCHEDULE B MAXIMUM PERMISSIBLE GROUND LEVEL CONCENTRATION
(in micrograms per cubic metre at standard conditions)

	Averaging Period			
Contaminant	1 Hour	8 Hours	24 Hours	1 Year
Carbon monoxide	35 000	15 000		
Hydrogen sulphide	15		5	
Nitrogen dioxide	400		200	100
Sulphur dioxide	900		300	60
Total Suspended particulate			120	70 (geometric mean)

7.1.7 **Newfoundland.**

Department of Consumer Affairs and Environment Act (Air Pollution Control Regulations)
Newfoundland Regulation 26/81 (as amended)
Department of Environment

The following articles are relevant to the management of biomedical waste:

9(1) No person shall cause or permit to be caused a visible emission having an opacity greater than density No. 1 on the Visible Emission Chart.

SCHEDULE 2 STANDARDS FOR EMITTED CONTAMINANTS

Item	Name of Contaminant	Unit of Measurement	Design Standard or Average Concentration or Total Amount of Contaminant	Approximate Equivalents of Column 3 Where Appropriate (at Standard Conditions)	Period of Time
7	Hydrogen Chloride	mgms of HCl/ m^3 of air	100	0.07 ppm	30 min
17	Suspended Particulate Matter	mgms of S.P.M./ m^3 of air	100		30 min

7.2 Federal

7.2.1 Agriculture Canada.

Animal Disease and Protection Act, Regulations Respecting Animal Diseases and Protection

Under these regulations, a "communicable disease" means an infectious or contagious disease.

Section 114 prescribes that "a veterinary inspector may order the person having the possession, care or custody of an animal that dies and is suspected of having died of a communicable disease or is destroyed persuant to Section 11 of the Act, to dispose of its carcass in such a manner as a veterinary inspector may specify."

No provisions are made as to the manner of disposing of contaminated carcasses.

7.2.2 Fisheries and Oceans Canada.

Fisheries Act, Subsection 33(2)

This subsection prohibits the deposition of deleterious substances into fisheries wasters except as may be permitted by regulations. This Act applies to waters frequented by fish or waters leading to fish-frequented waters.

7.2.3 Transport Canada.

Transportation of Dangerous Goods Act and Regulations

The following are the sections of the Transportation of Dangerous Goods Regulations that may be relevant to biomedical wastes transportation by any means:

Section 2.3 These regulations do not apply to the handling, offering for transport or transporting by any means of transport

(d) of low concentration hospital waste or other low concentration wastes of a medical nature, other than infectious substances set out in Schedule VII and radioactive material;

(k) of environmentally hazardous substances that are included in Division 2 of Class 9 and that are

i) in quantities that are permitted in foods pursuant to the Food and Drug Act;

iv) substances that are in quantities less than 0.01 per cent by mass if these substances are not regulated by the Food and Drug Act, the Environmental Contaminants Act, or the Feeds Act.

(m) of biological products that are finished biological products, including live vaccines, or unfinished biological products and attenuated live vaccines for

i) human or veterinary use,

ii) development or investigational purposes for use in humans or animals, or

iii) experimental treatment of animals, and such biological products are prepared in accordance with the procedures set out by or under the Food and Drugs Act but the exportation of which may be subject to the authorization of the country of destination.

Criteria of Classes and Packing Groups for Classifying not Fully Specified Dangerous Goods:

Class 6 - Poisonous (toxic) and Infectious Substances

Section 2.33 No person shall handle, offer for transport or transport dangerous goods in a means of transport where dangerous goods

(d) are included in Division 2 of Class 6 and are packaged together with any other dangerous goods in the same outer packaging.

Section 3.19 Not fully specified products or substances that

(f) are organisms that are infectious or that are reasonably believed to be infectious to humans or to animals and the toxins of such organisms, shall be included in Class 6 referred to in the schedule to the Act.

Divisions - Class 6 (Poisonous (toxic) and Infectious Substances)

Section 3.20 Products or substances included in Class 6 pursuant to Section 3.19 shall be included in

(b) Division 2, if they are included in Class 6 pursuant to paragraph 3.19(f).

Packing Groups - Class 6 (Poisonous (toxic) and Infectious Substances)

Section 3.21(1) Subject to subsection (2) and (3), Products or Substances included in

(b) Division 2 of Class 6 pursuant to paragraph 3.20(b) shall be included in Packing Group I.

(2) Subject to subsection (3), where products or substances included in Class 6 pursuant to paragraphs 3.19(a) to (e) meet the criteria for more than one packing group, they shall be included in the packing group with the lowest roman numeral.

Shipping Document

Division 2 of Class 6 (Infectious Substances)

Section 4.10 Where the shipping document referred to in Section 4.4 relates to dangerous goods that are included in Division 2 of Class 6 and that originate in Canada, the shipping document shall indicate, in addition to any information required by Section 4.8,

(a) the following words set out in a prominent manner: "If package damaged, immediately telephone CANUTEC, (613) 996-6666" or "Si le colis est endommagé, téléphoner immédiatement à CANUTEC (613) 996-6666";

(b) where the infectious substances are a diagnostic specimen, the words "Diagnostic Specimen" or "Echantillons pour diagnostic" and the name of the suspected micro-organism; and

(c) where the infectious substances are not a diagnostic specimen, the name of the micro-organism.

Sections 4.15 - 4.19 and 4.22 - 4.27 These sections regard the documentation needed for transporting dangerous goods that are (a) solid wastes in quantities of 5 kg or more, or (b) liquid wastes in quantities of 5 L or more.

Section 5.7 (1) Before dangerous goods are transported, the consignor of the dangerous goods shall display on every small container and every package that contains the dangerous goods

(a) a label that corresponds to the label set out in Part I of Schedule V for the primary classification of the dangerous goods

(see Figure 7.1 which applies for Infectious Substances)

Section 5.17 Subject to section 5.18, where a domestic consignment or a transborder consignment of a mixed load of dangerous goods having different classifications, other than a consignment that includes

(a) any of the dangerous goods referred to in paragraph 5.16(c)
(b) explosives,
(c) organic peroxides,
(d) poison gases,
(e) corrosive gases, or
(f) radioactive material,

is to be transported in a large container or a transport unit, the person in charge of the large container or the transport unit may display on the large container or the transport unit a placard that corresponds to the placard set out as Figure 19 in Part II of Schedule V with the letters not less than 50 mm high and a stroke not less than 10 mm wide, instead of any other placards or orange panels required by this part for the dangerous goods.

Section 5.19(1) No placard is required to be displayed on a road vehicle that is travelling solely on land, other than on a railway vehicle, and that contains

(c) 500 kg or less gross quantity of dangerous goods, other than

(vii) wastes

Other Safety Marks - General

Section 5.37(1) Before a small container or a package containing dangerous goods is transported, the consignor of the dangerous goods shall mark clearly and legibly on any surface of the small container or the package other than the surface on which the container or package is intended to rest during transport

TDGR Schedule V -- Part I, Figure 16, Class 6, Division 2.

Infectious Substances Label

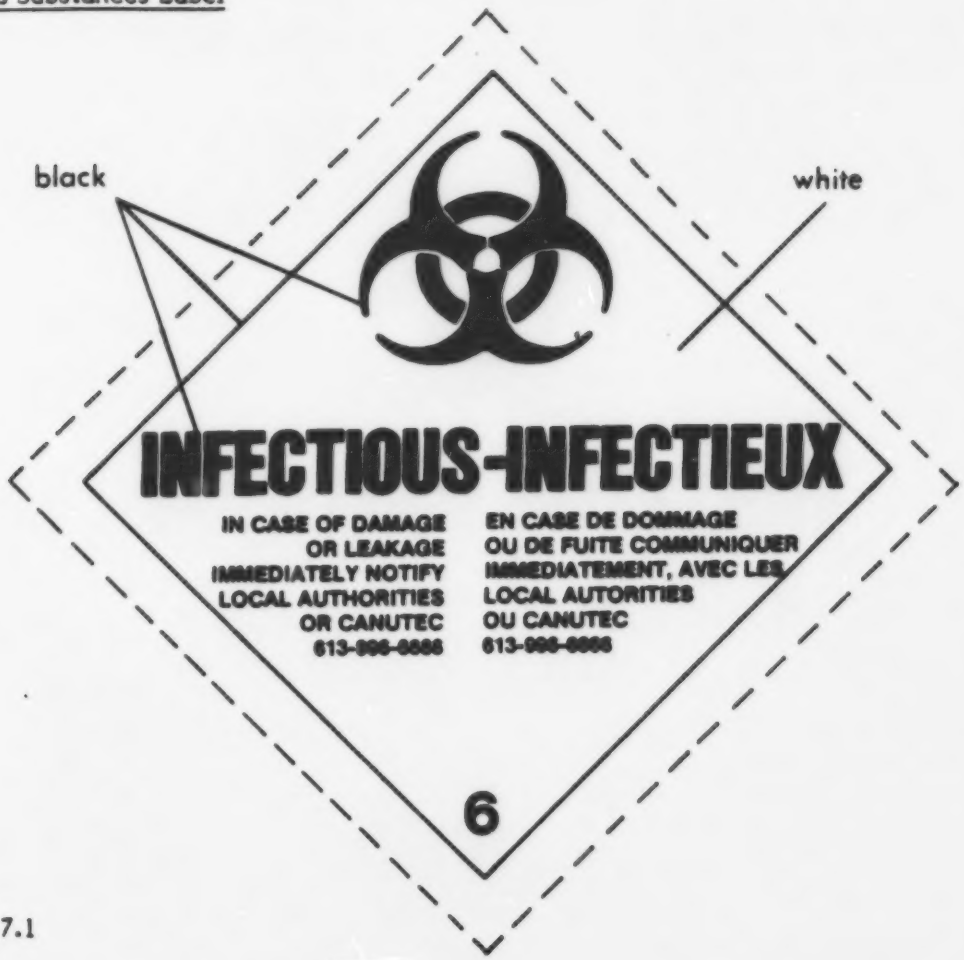


FIGURE 7.1

(a) the shipping name of the dangerous goods;

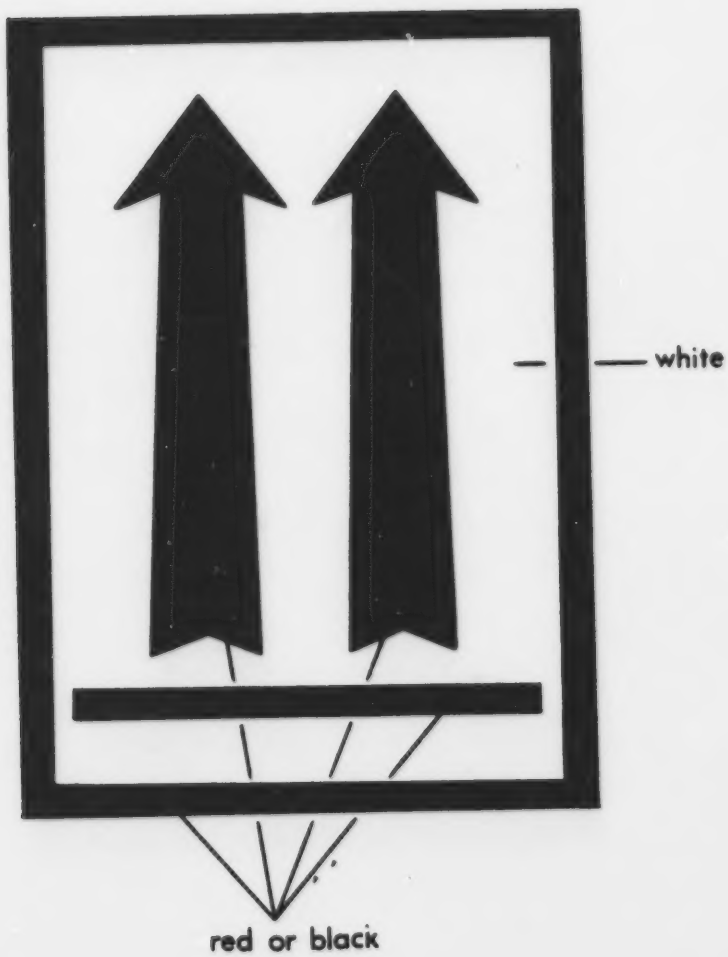
(c) except for dangerous goods included in Class 1, the product identification number preceded by the letters "PIN" or "NIP", or the letters "UN" or "NA" determined in accordance with section 2 of the Legend to List I and List II of Schedule II;

(e) Where the small container or the package contains a liquid in an inner receptacle or inner packaging, a safety mark that corresponds to the safety mark set out as Figure 3 in Part IV of Schedule V, and

(ii) in the case of infectious substances packed in small packages, the safety mark shall be rectangular in shape and shall have dimensions of not less than 52.5 mm high and 37 mm wide. (Figure 7.2)

FIGURE 7.2

TDGR Schedule V -- Part IV, Figure 3
Package Orientation



(2) Where, pursuant to subsection (1), a safety mark is required to be displayed on a small container or package and the small container or package is contained in an overpack, in addition to the requirements of subsection (1), the consignor of the dangerous goods shall display the safety mark on the overpack if the safety mark displayed on the small container or package is not visible.

Division 2 of Class 6 (Infectious Substances)

Section 7.8 (1) no consignor shall offer for transport an infectious substance included in Division 2 of Class 6 to a carrier unless:

(a) he has received notification from the consignee that receipt of the goods is not prohibited by any applicable law at the point of destination or in any country through which the goods may transit; and

(b) he notifies the consignee of

i) the date of shipment and of expected arrival,

ii) the identification of the means of transport to be used, and,

iii) the shipping document identification number.

Section 7.15 For the purposes of section 7.16 to 7.19, "emergency" means a present or imminent event that requires prompt co-ordination of action for the protection of public safety, property or the environment; "plan" means a written statement outlining the emergency response assistance capability of an organization in the event of an emergency.

Section 7.16 (1) Subject to section 7.18, no person shall offer for transport any dangerous goods set out in Schedule XII from a point in Canada to a destination in or outside Canada unless the person has filed, or caused to be filed, with the Director General a summary of a plan in respect of the dangerous goods.

(2) Every consignee of a consignment of dangerous goods set out in Schedule XII shipped from a point outside Canada to a destination in Canada shall file, or cause to be filed, with the Director General a summary of a plan in respect of the dangerous goods.

(3) No road or rail carrier shall transport any dangerous goods set out in Schedule XII from a place outside Canada to a place outside Canada, through Canada for a distance greater than 70 km, unless the carrier has filed, or caused to be filed, with the Director General a summary of a plan in respect of the dangerous goods.

Section 7.17 Every person required to file a summary of his plan shall set out in that summary the following information as applicable:

(a) the name and address of the agent, if any, filed pursuant to Part XII;
(b) a brief description of his emergency response capability;
(c) certification that an emergency response capability exists;
(d) a brief description of the means by which the plan can be activated;
(e) the name, address, telephone number, function, and signature of the person submitting the summary of the plan; and
(f) the name of the person on whose behalf the summary of a plan is filed.

Section 7.18 Where dangerous goods listed in Column I of Schedule XII are assigned the Special Provision S1, S2, S3, S4 or S5 in Column IV of that Schedule, every person required to file a summary of a plan under this Part in respect of those goods shall file a summary of his plan for the quantities of those goods as follows:

(a) S1, for any quantity;
(b) S2, for quantities exceeding 15 g net;
(c) S3, for quantities exceeding 25 kg or litres net per consignment;
(d) S4, for quantities exceeding 1,000 kg or litres net per consignment; or
(e) S5, for quantities exceeding 3,000 kg or litres net per container.

Section 7.19 The Director General, upon receipt of a summary of a plan filed pursuant to this Part, shall assign a reference number to the summary of plan and shall provide the person who filed the summary of the plan with the reference number.

Notification of Lost, Stolen or Misplaced Goods

Section 9.10 Where a person discovers that all or part of a consignment of dangerous goods has been lost, stolen or misplaced

(a) in the case of dangerous goods included in Class 1, Division 2 of Class 6 or Class 7, the person shall immediately report the discovery to the local police; and
(b) in the case of dangerous goods included in Division 2 of Class 6, the person shall immediately cause the discovery to be reported to CANUTEC at (613) 996-6666.

Schedule III - Special Provisions

46. No person shall offer for transport or transport this substance as limited quantities or consumer commodities.

48. No person shall offer for transport or transport this article, product or substance.

65. No person shall offer for transport or transport the infectious substances, human or animal, set out in Schedule VII, unless these infectious substances are packaged in accordance with CGSB Provisional Standards 43-GP-125 MP, "Provisional Standard for: Packaging of infectious substances", dated January, 1984.

66. Where infectious substances are hazardous to both animals and humans, the consignor shall use the shipping name "Infectious substances, human, n.o.s.", and the product identification number 2814.

67. No person shall offer for transport or transport infected live animals.

78. No consignor shall pack this product or substance with any other product or substance in the same outer packaging.

100. Where these products or substances are included in an international consignment and are offered for transport or transported by ship, the consignor shall comply with the requirements of the IMDG Code and, in the case of Oxygen or Oxygen, compressed (PIN 1072), or Oxygen, refrigerated, liquid, or Oxygen, pressurized, liquid (PIN 1073) that is included in a consignment other than an international consignment and that are transported by ship, with the requirements of the Dangerous Goods Shipping Regulations.

TABLE 7.1 TDGR SCHEDULE VII - INFECTIOUS SUBSTANCES

---

1. For the purpose of these Regulations, infectious substances are divided into three groups as follows:

   (a) Group 1A, are the most dangerous infectious substances and includes

      (i) the Infectious Substances listed in Table 1 to this Schedule, and (ii) any other infectious substances that

         (A) have a degree of virulence similar to that of any substance listed in that Table,

         (B) pose a risk to the community similar to the risk posed by any substance listed in that Table,

         (C) are resistant to available treatment or for which no treatment is available, or

         (D) are diagnostic specimens that are likely to contain any of the substances listed in that Table;

TABLE 7.1 TDGR SCHEDULE VII - INFECTIOUS SUBSTANCES (Cont'd)

(b) Group 1B, are dangerous infectious substances less dangerous than the infectious substances included in Group 1A and includes

(i) the Infectious Substances listed in Table II to this Schedule, and (ii) any other infectious substances that

(A) have a degree of virulence similar to that of any substance listed in that Table,

(B) pose a risk to the community similar to the risk posed by any substance listed in that Table,

(C) are resistant to available treatment or for which no treatment is available, or

(D) are diagnostic specimens that are likely to contain any of the substances listed in that Table;

(c) Group 1C, are dangerous infectious substances that are less dangerous than the infectious substances in Group 1B and includes

(i) infectious substances that are not included in Group 1A and Group 1B but that pose a significant risk to the individual or the community, and

(ii) any diagnostic specimens that are likely to contain any of the substances referred to in subparagraph (i).

TDGR SCHEDULE VIIINFECTIOUS SUBSTANCES

TABLE I

Infectious Substances, Human

Ebola virus

Hemorrhagic fever agents, including Crimean hemorrhagic fever (Congo), Junin, Machupo, Bolivian and Korean hemorrhagic fever viruses

Herpesvirus simiae (B virus)

Lassa virus

Marburg virus

Rift Valley Fever virus

Tick-borne encephalitis virus complex including Russian spring-summer encephalitis, Kyasanur forest disease, Omsk hemorrhagic fever and Central European encephalitis viruses

Whitepox viruses

Variola major or minor

Infectious Substances, Animal

African swine fever virus
Borna disease virus
Foot and mouth disease virus
Fowl plague virus
Goat pox virus
Hog cholera virus
Lumpy skin disease virus
Mycoplasma mycoides subspecies mycoidses pathovar bovis
Newcastle disease virus
Pasteurella multocide type B
Peste des petits ruminants virus
Pseudorabies virus
Rinderpest virus
Sheep pox virus
Swine vesicular disease virus
Teschen disease virus
Vesicular exanthema virus
Vesicular stomatitis virus

TABLE II

Infectious Substances, Human

Actinobacillus mallei
Arborvirus, all species
Bacillus anthracis
Bartonella, all species
Brucella abortus
Brucella melitensis
Chlamydia psittaci
Coccidioides immitis
Coxiella burnetti
Francisella tularensis
Histoplasma capsulatum
Lymphocytic choriomeningitis virus (LCM)
Mycobacterium bovis
Mycobacterium tuberculosis
Rabies virus
Rickettsia, all species
Yersinia pestis
Hybrid or mutant organisms developed during laboratory procedures, including DNA (deoxyribonucleic acid) recombinations, that require physical containment level D or higher by the Guidelines produced by the Medical Research Council of Canada entitled "Directives for the handling of recombinant DNA and animal viruses and cells".

Oncogenic viruses that require physical containment level D or higher by the Guidelines of the Medical Research Council of Canada.

8 CONCLUSION AND RECOMMENDATIONS

The trend to use disposable medical and laboratory supplies has dramatically increased the biomedical waste load from health care facilities in Canada. In hospitals alone, up to 20,000 tonnes are produced annually. This tendency has been dictated mainly by economical and personnel safety factors. Unfortunately, this extra load to the environment has often not been managed properly, resulting in an elevated risk for injuries and the spread of disease. In Canada, there are technologies, operational guidelines and to some degree, legislation to address those risks. Because of economical restrictions, or sometimes the ignorance of administrators, these tools are often neglected.

The highlights of the best available management technologies are the following:

1. Segregation

Complete segregation of hospital waste as to their degree of hazard has often been judged as non-practicable by administrators. Some hospitals will consider everything that has been in contact with a patient (contageous or not) as potentially infectious. Used items will be discarded with the same precautions used for wastes which have been ascertained as infectious.

Once determined what should be considered as an infectious waste a pathological waste, or any other type, the next step is to ensure that the segregated wastes are all stored in the same group of containers or colour coded containers. The colour coding will indicate to the workers picking up the waste as to which set of predetermined procedures are to be followed.

The risk with colour coding is that it may (and it will) differ from one establishment to another defeating its original purpose of proper segregation. It is, therefore, important that colour codes are standardized among waste generators so that the transporters and the disposal facilities know what they are dealing with. Such a standard exists in Canada and this study found that many health care administrators are ignorant of it or simply not using it.

2. Treatment

The most common treatment method in use among biomedical waste generators is by far autoclaving. This steam sterilization device can eliminate pathogens

very efficiently. It has, however, some limitations and, therefore, cannot be efficient for all types of waste. Operators should be well aware of the different standards established for different loads (type of waste, type of container, volume and configuration, etc.).

3. On-Site Transportation

Because of their nature, biomedical wastes require proper handling by trained personnel when they are transported within the medical or research facility. For this reason mechanical or automated transportation systems are not suitable. The use of manual push carts can be optimized through careful planning of the routes, training of personnel, adequate sizing and construction of the carts, minimizing the handling and proper cleaning and maintenance of the fleet.

4. Off-Site Transportation

The need for transportation of biomedical waste has increased in the recent years. This is because many old on-site incinerators can no longer perform adequately. They were not originally designed to accommodate large quantities of disposable items (varying in composition) and therefore would need additional pollution control devices to meet emission guidelines.

Section 2.3(d) of the Transportation of Dangerous Good Regulations provides exemption for a "low concentration hospital waste or other low concentration waste of medical nature" from any particular precaution when in transit. Therefore, there are no mechanisms in place to identify vehicles transporting these wastes or to know their final destinations. Only those wastes containing or suspected to contain infectious substances from Schedule VII of the Regulations are regulated.

In Ontario, the Ministry of the Environment has taken a step forward by requiring that licensed biomedical waste haulers only accept treated pathological or infectious biomedical waste for transportation to an Ontario registered disposal site. If not properly sterilized, the biomedical waste has to be properly identified, packaged, colour coded and labeled with the approved biohazard logo and description of contents manifested in compliance with the Ontario manifest form requirements.

5. Incineration

The major issue associated with the on-site incineration of biomedical waste is the capability of existing facilities to properly remove particulates and hydrogen chloride gas before emissions leave the stack. The elevated cost for installing proper control

equipment (scrubbers) may force more institutions to share their incineration facilities as noted above. This practice exists already in many provinces (Section 4).

Historically, the multiple chamber incinerator has been used for burning biomedical wastes. Because of the ever increasing variation in the non-anatomical waste, the controlled air incinerator (starved air type) has been preferred since the 1970's. The controlled air incinerator provides higher combustion efficiency, lower particulate emission rates and easier operating control. The capital cost for a controlled air incinerator is approximately 20% higher than the multiple chamber type. The multiple chamber incinerator is still used for destruction of waste that exhibits little variation in composition such as anatomical wastes.

6. Landfill

Statistics in Canada do not document frequent incidents involving landfill workers contaminated with infectious waste. Experience gained from other countries, however, demonstrates the hazard to which these workers are exposed daily.

Characterization of hospital associated pathogens, disease causation, harmlessness of incineration residues (ash), landfill dynamics and their effects on pathogens, landfill selection and operation are among areas identified as requiring more research.

The literature review and the discussions with many managers dealing with biomedical wastes lead to the following recommendations:

1. Definition

The main weakness identified through the preparation of this manual has been the lack of a standard definition among the various generators and government levels. Although the classification scheme from the Canadian Standards Association and the resultant definition from the Ontario Ministry of the Environment set a precedent in Canada, a definition of biomedical waste without any ambiguities has yet to be developed. Terms such as "may be contaminated" must be eliminated (refer to Type A, Class 3 biomedical wastes). Also, these wastes have been found to be indiscriminately called biomedical, pathological, infectious, etc. causing a confusion as to the exact designation of each group.

It is therefore recommended that a uniform definition for biomedical waste be developed and adopted by all Provinces.

2. Guidelines

On a national basis, some Canadian associations and federal departments have guidelines in place addressing some aspects of biomedical waste management. Most of these address the personnel safety aspect within the work place (i.e. CSA and MRC Guidelines). Environment Canada should take a leading role in the development of environmental guidelines or code of good practices. These documents should address at least the following:

- The different disposal technologies available (incineration, landfilling, sewer line) by setting minimum requirements for an environmentally sound disposal;
- The requirements under TDGA for the transportation from the point of generation to the transfer station, the treatment facility or the disposal site.

3. Other Sources

The quest for information on biomedical wastes has been relatively successful with regard to two major generators: the Health Care Industry and the Veterinary Facilities. Characteristics, inventories, current management techniques and policies pertaining to biomedical wastes have been obtained through the generators, governmental agencies and the literature.

A comprehensive assessment of the Academic and Industrial Research Laboratories, the Pharmaceutical Industry and the Food, Drug and Cosmetic Industries is recommended. This could be achieved by conducting an inventory of the facilities from these sectors and then by sending questionnaires to a representative sample. This questionnaire would identify those facilities producing wastes corresponding to the definition of biomedical and would also require information on the facility's approach to their safe management.

4. Regulations in Other Provinces and Territories

In Canada, only two provinces have recognized biomedical wastes from health care and research facilities as requiring special management. The role of Environment Canada should be to promote the development of appropriate legislation with the other provinces and territories. A first step in that direction would be to distribute this document to all provinces and territories in order to help them better portray the current situation in Canada. The document should also be distributed to the Health Care Facilities for their input.

9 REFERENCES

Alberta. 1975. "Solid Waste Handling & Disposal in Alberta Hospitals". Alberta Department of Environment, Pollution Control Division.

Barbeito, M. S. , L. A. Taylor and R. W. Seiders. 1968. "Microbiological Evaluation of a Large Volume Air Incinerator". Applied Microbiology. 16: 490-495. In Iglar and Bond (1973).

Bleckman, J. R. 1984. "Hospital Waste Management Practices". Presented at Hazards 84 Conference. Houston.

Block, S. S. and J. C. Netherton. 1977. "Infectious Hospital Wastes: Their Treatment and Sanitary Disposal". Disinfection, Sterilization and Preservation. Edited by Seymour S. Block. 2nd Edition. Philadelphia. Lea and Febiger.

Bond, R. G., S. S. Arora, R. L. DeRoos, A. G. Duchêne, J. L. Jain and D. Vesley. 1973. "Study of the Economics of Hospital Waste Systems". US EPA. Cincinnati, Ohio.

Brenniman, G. R., R. J. Allen and P. J. Graham. 1984. "Disposal of Infectious Hospital Waste: the Problem in Illinois". The Environmental Professional. Vol. 6, pp. 247-253. USA.

Broderson, H. 1982. "Survey of the Collection, Recycling and Safe Disposal of Hospital Wastes in the Member States of the European Communities (Final Report)". Environment and Quality of Life. Commission of the European Communities. Luxembourg.

Burchinal, J. C. and L. P. Wallace. 1971. "A Study of Institutional Solid Wastes". Department of Civil Engineering. West Virginia University. Morgantown, Virginia.

Canada. 1978. Clean Air Act. "Packaged Incinerators National Emission Guidelines".

Canada. 1984. "A Study of Heat Recovery from Hospital Solid Waste Incineration". Health Services and Promotion Branch. Health and Welfare Canada. Ottawa.

Canada. 1985. "1985 Incineration Inspection and Evaluation Report". National Capital Area Operations. Environmental Protection Service. Ontario Region. Environment Canada.

Canadian Hospital Association. 1985. "1985 Canadian Hospital Directory. Buyer's Guide and Statistical Compendium". Volume 33. Ottawa, Ontario.

Canadian Standards Association. 1981. "Handling of Waste Materials Within Health Care Facilities". CSA Standard Z317.10-M 1981. Rexdale.

Doyle, B. W., D. A. Drum and J. D. Lauber. 1985. "The Smoldering Question of Hospital Wastes". Pollution Engineering. pp. 35-39.

Eaman, M. J., Chandler, A. J., Eaton, R. B. and Trotter, D. 1986. Interim National Emission Criteria for PCB Destruction Facilities. Prepared for Canadian Council of Resource and Environment Ministers.

Gordon, J. A., N. Zank, K. Brooks and L. Cofone. 1979. "Disposal of Hospital Waste Containing Pathogenic Organisms". The Mitre Corporation. McClean, Virginia.

Gore & Storrie Limited. 1982. Canadian National Inventory of Hazardous Wastes. Environmental Protection Service. Environment Canada.

Iglar, A. F. and R. G. Bond. 1973. "Hospital Solid Waste Disposal in Community Facilities". School of Public Health, University of Minnesota. Minneapolis, Minnesota.

Jan, W. 1984. Characterization of Hazardous Wastes from Small Quantity Waste Generators (Non-Manufacturing) - A Preliminary Overview. Unpublished report. Waste Management Branch. Environmental Protection Service. Environment Canada.

Kremer, J. G., F. D. Dryden and S. J. Hyland. 1977. "Disposal of Hospital Infectious Solid Wastes to the Sewerage System". Proceedings of the 30th Industrial Waste Conference May 6, 7, and 8, 1975. Ann Arbor Science Publishers Inc. Michigan.

Lapedes, Daniel N. 1978. Dictionary of Scientific and Technical Terms. Second Edition. McGraw-Hill.

Dr. Ling personal conversation. 1986. Physiology Department. Dalhousie University. Halifax, NS.

Manuel, J. 1985. "A Strategy for Handling and Disposal of Biomedical Wastes". Ontario Ministry of the Environment. Presented at the Industrial Waste Conference. Toronto.

McRae, A. M. 1980. Solid Waste Incineration and Heat Recovery at the Royal Jubilee Hospital in Victoria, B. C. Environmental Protection Service. Pacific Region. Environment Canada.

McKee, R. W., P. C. Owzarski, C. D. Butcherite and J. W. Frymier. 1973. " Feasibility of a Large Gamma Irradiator as a Hospital Sterilization Facility". U.S. Atomic Energy Commission. Report BNWL-1723 VC-23.

Michaelson, G. S. 1963. "Waste Handling". In Proceedings of the National Conference of Institutionally Acquired Infections. Minneapolis. U.S. Public Health Service Publication 1188. U.S. Government Printing Office. Washington. pp. 65-69. In Iglar and Bond (1973).

Murnyak, G. R. and D. C. Guzewich. 1982. "Chlorine Emissions from a Medical Waste Incinerator". Journal of Environmental Health. Vol. 45(2).

New Brunswick. 1985. Data Compiled for the Preparation of the "Hazardous Wastes Generation in New Brunswick - 1985 - Status Report". Environment New Brunswick.

Norris, F. S. And B. G. Young. 1978. "Guidelines for Defining and Disposing of Medical Waste". Aviation, Space and Environmental Medicine. Vol. 49.

Nova Scotia. 1979. Hazardous Waste Survey of Medical Facilities. Nova Scotia Department of the Environment. Unpublished Report.

Ontario. 1986. Incinerator Design and Operating Criteria. Volume II. Biomedical Waste Incinerators. October 1986. Ontario Ministry of the Environment. Toronto. Ontario.

Peterson, M. L. and F. J. Stutzenburger. 1969. "Microbiological Evaluation of Incineration of Incinerator Operations". Applied Microbiology. 18: 8-13. In Stachiw (1976)

Pollock, E. L. 1978. "Use of One-Time Materials and Equipment Increases Hospital Refuse". Solid Wastes Management.

Reavely, G. H. and P. G. Warwick. 1971. "The Disposal of Infectious Hospital Waste". London Hospital Planning Council, London, Ontario.

Rich, G. And K. Cherry. 1986. "The Liabilities of Hospital Waste Incineration". Pollution Engineering. p. 48.

Stachiw, K. P. 1976. "Medical Facility Solid Waste Management". USA Environmental Hygiene Agency, Solid Waste Management Division. Aberdeen Proving Ground, Maryland.

United States Environmental Protection Agency. 1979. Technical Environmental Impacts of Various Approaches for Regulating Small Hazardous Waste Generators. Vol. I and II. Office of Solid Waste. Washington, D. C.

United States Environmental Protection Agency. 1982. "Draft Manual for Infectious Waste Management". Office of Solid Waste and Emergency Response. SW-957. Washington.

United States Environmental Protection Agency. 1986. EPA Guide for Infectious Waste Management. Office of Solid Waste and Emergency Response. Washington, D. C. EPA/530-Sw-86-014.

University of California in Los Angeles. 1974. "Hospital Wastes Management Study of Los Angeles County. University of Southern California Medical Center". Prepared by the School of Public Health. Environment Health Management Program. In Stachiw (1976).

University of Minnesota. 1971. "Study of Economics of Hospital Solid Waste Systems - Progress Report, June 1, 1970 - May 31, 1971". Division Environmental Health. School of Public Health. In Wilson (1977).

Wallace, L. P., R. Zaltman and J. C. Burchinal. 1972. "Where Solid Waste Comes From; Where it Should Go". Modern Hospital. 118: 92-95. In Iglar and Bond (1973).

Weintraubard, B. S. and H. D. Kern. 1969. "Use of Wet Grinding Units for Disposal of Hospital Solid Wastes". Los Angeles Health Department, Los Angeles. In Block and Netherton (1977).

World Health Organization. 1983. "Management of Waste from Hospitals and Other Health Care Establishments". Report on a WHO Meeting. Euro Reports and Studies 97. Bergen.

APPENDIX

APPENDIX 1 DEFINITION OF BIOMEDICAL WASTE ADOPTED BY THE ONTARIO MINISTRY OF THE ENVIRONMENT (Guidelines for the Handling and Disposal of Biomedical Wastes from Health Care Facilities and Laboratories.) 1986.

1.0 DEFINITION AND CLASSIFICATION OF WASTE

1.1 Biomedical Waste

Biomedical waste originates in health care facilities, doctors' offices, diagnostic and research laboratories and mortuaries. This waste may be hazardous to public health and may include anatomical waste such as human or animal tissue and body parts.

Biomedical waste for the purposes of these guidelines includes both pathological waste and infectious waste. Communicable diseases are defined in schedules of the Ontario Health Protection and Promotion Act 1983 and the Canada Animal Disease and Protection Act.

1.1.1 Pathological Waste. Pathological Waste is a waste that is any of the following:

(1) Human anatomical waste including any part of the human body with the exception of extracted teeth, hair, nail clippings and the like.

(2) Animal anatomical waste which is all or part of a carcass suspected of being infected with a disease communicable to humans or animals.

1.1.2 Infectious Waste. Infectious waste is waste of any type which is contaminated or suspected to be contaminated with the causative agents of infectious disease or their toxic products and capable of infecting or causing disease in susceptible individuals or animals exposed to them.

To be classified as "infectious", waste should not merely contain pathogens but should also be capable of transmitting infection. An understanding of the factors necessary for transmission of infection is useful in classifying waste as infectious.

Infectious waste may include:

(1) Human anatomical;

(2) Animal anatomical;

(3) Non-anatomical;

(4) Microbiological;

(5) Blood, blood products, and body fluids suspected to contain microbial agents of disease;

(6) Waste generated by patients in isolation (for communicable diseases).

1.2 Other Biomedical Waste Requiring Special Handling

Waste other than those biomedical waste categories described above may be generated from time to time and shall be disposed of properly. These are:

(1) Hospital and health care waste considered not to be infectious.

(2) Non-anatomical waste that has been decontaminated in a device approved for that specific purpose.

(3) Sharps (e.g. needles, scalpels, etc.).

(4) Radioactive waste, chemical and chemotherapy waste, and organic waste (solvents) are not included in these guidelines. Reference should be made to other publications dealing with the safe handling and disposal of these waste categories.

APPENDIX 2 U.S. ENVIRONMENTAL PROTECTION AGENCY DEFINITION OF INFECTIOUS WASTES (US EPA (1982))

Infectious Wastes: "Wastes that in all probability contain pathogenic agents that - because of their type, concentration and quantity -may cause disease in persons exposed to the waste".

This designation is based on waste type rather than on the source of the waste. Therefore, a particular type of infectious waste may be generated by different industries and by more than one source within a facility.

EPA classifies infectious wastes into 13 categories:

- isolation wastes
- cultures and stocks of ethiologic agents
- blood and blood products
- pathological wastes
- other wastes from surgery and autopsy
- contaminated laboratory wastes
- sharps
- dialysis unit wastes
- animal carcasses and body parts
- animal bedding and other wastes from animal room
- discarded biologicals
- contaminated feed and other products
- contaminated equipment.

APPENDIX 3 WASTE GENERATION RATES AT SELECTED AMERICAN HOSPITALS (Covering period 1966-1977)

Generation Rate (a) kg/patient/day (b) kg/bed/day	Size of Hospital (beds)	Date of Survey	Reference
(a) 2.1 - 7.35 (b) 3.78	50-1226	1966-1970	Iglar and Bond (1973)
(a) 1.63 (b) 1.31	438	1968-1971	Burchinal and Wallace (1971)
(b) 3.02	N/A	1968	Pollock (1978)
(a) 2.78 (b) 2.22	430	1971	University of Minnesota (1971)
(b) 4.06	N/A	1974	Pollock (1978)
(b) 4.28	N/A	1975	
(b) 3.69	N/A	1975	
(a) 4.35 - 4.76 (b) 3.90 - 4.31	630	1975	
(b) 8.16 - 9.07	N/A	N/A	
(a) 7.80 (b) 6.24	N/A	N/A	Kremer et al. (1977)
(a) 4.54 - 18.16 (b) 9.08	N/A	N/A	Block and Netherton (1977)

N/A: Not Available

APPENDIX 4 WASTE GENERATION RATES AT SELECTED CANADIAN HOSPITALS
(Covering period 1971-1985)

Generation Rate (a) kg/patient/day (b) kg/bed/day	Size of Hospital (beds)	Date of Survey	Reference
(a) 1.57 - 4.54 (b) 2.55	59-900	N/A	Reavely and Warwick (1971)
City A Hospital: (a) 5.66 (b) 1.83	52-1048	1975	Alberta (1975)
City B Hospital: (a) 4.0 (b) 3.47	100-952	1975	
Small Communities H: (b) 1.8	8-329	1975	
(b) 6.0	250	N/A	Manuel (1985)
(a) 3.5	720		Canada (1984)
(a) 3.2	320		
(a) 2.1	124		
(b) 3.3	720		
(b) 2.9	320		
(b) 1.5	124		

N/A: Not Available

APPENDIX 5 WASTE GENERATION RATES AT SELECTED CANADIAN HOSPITALS
(Covering period 1971-1985)

Generation Rate (a) kg/patient/day (b) kg/bed/day (c) % of total waste	Size of Hospital (beds)	Date of Survey	Reference
(c) 25-30	N/A	N/A	Burchinal and Wallace (1971)
(a) 0.73-2.36 (b) 0.58-1.89	59-600	N/A	Reavely and Warwick (1971)
(b) 0.0014-0.069	45-213	1985	New Brunswick (1985)
(a) 0.07 (a) 0.064 (a) 0.042 (b) 0.066 (b) 0.058 (b) 0.03 (c) 2	720 320 124 720 320 124	1984	Canada (1984)
(b) 0.6 (c) 10	250	N/A	Manuel (1985)
1.0 kg/ICU bed/day	N/A	N/A	Manuel (1985)
(c) 10	N/A	N/A	Bleckman (1984)
(b) 0.034-0.141 (average-0.081)	76-406	1975	Alberta (1975)
(a) 0.037 (b) 0.029	N/A	N/A	Kremer et al. (1977)

N/A: Not Available

APPENDIX 6 MANAGEMENT OF BIOMEDICAL WASTE IN ALBERTA HOSPITALS (Detailed Information)

In 1975, the Alberta Department of Environment commissioned a survey of solid waste handling and disposal practices throughout the province. Based on that document, the following information portrays the 1975 biomedical waste management situation in Urban and Community Hospitals.

Urban Hospitals (24 hospitals surveyed)

i) Internal Handling

Sorting and segregation are determined by the type of final disposal. Double-bagged, contaminated wastes are indiscriminately collected into the same containers holding general wastes. In summary:

Thirteen (13) hospitals segregate combustible and non-combustible wastes;
Nine (9) use gravity chutes with manual carts (generally in hospitals larger than 500 beds);
Thirteen (13) double-bag contaminated wastes;
One (1) autoclaves dressings and biological wastes prior to collection intended for landfilling;
Ten (10) landfill contaminated wastes without treatment; of their total waste, these hospitals report 5% as being contaminated;
Eleven (11) segregate sharps at the source, box them, and dispose of them separately.

ii) Final Disposal

Twelve (12) hospitals incinerate contaminated and combustible waste and landfill the rest;

One (1) incinerates contaminated wastes only and landfills the rest;
Eight (8) landfill all their wastes.

Small Community Hospitals (126 hospitals surveyed)

i) Internal Handling

As for the urban hospitals, the internal handling practices are dictated by the mode of final disposal (i.e., combustible separated from non-combustible if the waste is

incinerated). The methods of handling and disposal for the 126 hospitals surveyed are summarized below:

Double-bagging of contaminated wastes	69%
Autoclaving of contaminated wastes	2%
Special handling of needles and sharps	9%
No special mention of contaminated wastes	20%

ii) Final Disposal

Incineration of contaminated combustible wastes; rest landfilled;	64%
Incineration of contaminated wastes only; remainder landfilled;	16%
Incineration of paper wastes only; remainder landfilled;	5%
Landfilling of all wastes;	12%
Method of disposal not reported	3%

APPENDIX 7 MANAGEMENT OF BIOMEDICAL WASTE IN NOVA SCOTIA HOSPITALS (Detailed Information)

The following information is based on an unpublished survey done by the Nova Scotia Department of the Environment in 1979 (Nova Scotia, 1979), and personal communication with Halifax and regional hospital administrators. The management practices for Type A, Classes 1 and 3 are as follows:

Type A, Class 1 - Human Anatomical Wastes

- The human anatomical wastes from the pathology departments and the operating rooms are collected on a special routine and incinerated; the ash is then compacted and taken to the landfill; or these wastes are simply reported as being incinerated.
- The anatomical non-contaminated wastes are bagged, compacted and landfilled; or collected on a special routine and incinerated on-site with the ash compacted and taken to the landfill; or simply landfilled (placenta and small tissue); or incinerated off-site (large tissue).

Type A, Class 3 - Non-Anatomical Wastes

- The contaminated laboratory equipment and material and the wastes from nursing care and other sources may be steam autoclaved before being incinerated off-site with ash compacted and taken to the landfill (glassware and culture media); or bagged and incinerated on-site; or chemically neutralized and then landfilled (microscope slides); or sent to the sewer (blood samples); or simply landfilled (blood taking equipment and surgical dressings).
- The sharps items (needles, blades, broken glassware) are rendered unusable and/or collected in special containers, incinerated on-site and the ash taken to the landfill; or chemically neutralized, compacted, and then taken to the landfill; or steam autoclaved off-site; or steam autoclaved and incinerated on-site.

APPENDIX 8 MANAGEMENT OF BIOMEDICAL WASTE IN NEW BRUNSWICK HOSPITALS

Based on information received from the New Brunswick Department of the Environment (ENB, 1985), the management practice of biomedical Type A wastes in this province could be largely segregated between Type A Classes 1 and 3 or Human Anatomical and Non-Anatomical Wastes.

Within a class, the wastes are managed according to their hazard (infectious or non-infectious) or their department of origin.

Type A, Class 1 - Human Anatomical Wastes

- The anatomical non-infectious wastes from the pathology departments, or laboratories, are placed in plastic bags or rigid containers and then incinerated.
- The anatomical non-infectious wastes from the operating rooms are either boxed and incinerated off-site or disposed of at the local dump.
- The anatomical infectious wastes from the operating rooms or wards are bagged and incinerated or disposed of down the sewers.

Type A, Class 3 - Non-Anatomical Wastes

- The contaminated laboratory equipment and material and wastes from nursing care or other sources are individually bagged; or steam sterilized at 126°C for 25 minutes; or rendered unusable and enclosed in impermeable rigid containers and then landfilled; or incinerated on-site; they may be bagged, compacted and landfilled; or collected on a special routine, incinerated on-site and the ash landfilled; or simply landfilled (dressings and plaster casts).
- Specimens from microbiology labs are disposed of via the sewer; incinerated on-site; or added to 1% javex, then autoclaved and incinerated on-site.
- Antineoplastic wastes such as outdated drugs and contaminated material are neutralized, autoclaved and then landfilled or incinerated; or simply bagged before being incinerated.